Technical Report 1064

Simulation-Based Communications Realism and Platoon Training in the Close Combat Tactical Trainer (CCTT)

Dorothy L. Finley
U.S. Army Research Institute

June 1997

United States Army Research Institute for the Behavioral and Social Sciences

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EDGAR M. JOHNSON
Director

Technical review by

Carl W. Lickteig, ARI-Knox
Rex R. Michel, ARI-Leavenworth
Robert B. Porter, 16th Calvary Regiment

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Training needs have long existed for skills in tactically dealing with variations in communications capability that occur on dynamic battlefields. These communications realism training needs are becoming more critical with the many advances in electronic communications technology. The new Close Combat Tactical Trainer (CCTT) will be the first training environment developed to simulate variations in electronics communications quality as would occur realistically. The CCTT was used to examine tactical communications training needs and simulation-based training strategies for Armor and Mechanized Infantry platoons. Communications realism simulation capabilities of an initial version of the CCTT were then evaluated in light of these training needs and strategies. Overall communications realism training requirements for warfighters were found to constitute a general model that effectively served as an instrument to define platoon training requirements. Structured training was identified as the most appropriate training. It is recommended that these stages be designed into vignettes or tables integrated into exercises developed to meet platoon training goals related to maneuver and engagement. Possible enhancements to CCTT's simulation of communications realism were also identified and their potential payoffs discussed.

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Simulation-based training	Structured training	Realistic communications training
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Dorothy L. Finley
U.S. Army Research Institute

Armored Forces Research Unit
Barbara A. Black, Chief

U.S. Army Research Institute for the Behavioral and Social Sciences
5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600

Office, Deputy Chief of Staff for Personnel
Department of the Army

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FOREWORD

The Close Combat Tactical Trainer (CCTT) is being developed to meet command, control, and communications maneuver element training needs. The CCTT is important to the Army because these combined arms training needs are critical and cannot be met effectively under current conditions. An example of currently unmet training needs is the preparation of warfighters to anticipate, and to avoid or cope with realistic degradation in electronic communications. The CCTT will be the first training environment designed to provide this aspect of battlefield reality.

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) is committed to supporting the fielding of CCTT through determining how to best take advantage of its capabilities. This report defines training requirements and outlines a structured training strategy for platoons conducting tactical operations under completely realistic communications conditions. Limitations in CCTT's simulation of realism are discussed in terms of training value and how unmet training needs might be satisfied. Problem analyses drew on information from many sources, including the U.S. Army's Signal Center, Armor Center, U.S. Army Simulation, Training, and Instrumentation Command, and U. S. Army Communications and Electronics Command. Also critical to an understanding of this problem area were findings from the Army's Advanced Warfighting Experiments.

This investigation was performed under Science and Technology Objective IV.0.6, Research Task 2228, FASTTRAIN, Force XXI Training Methods and Strategies. The definition of communications training requirements and structured training strategy will provide supplements to CCTT structured training support packages. These will also provide a basis for articulating communications realism requirements and strategy for other training media and audiences.

ZITA M. SIMUTIS
Technical Director

EDGAR M. JOHNSON
Director

SIMULATION-BASED COMMUNICATIONS REALISM AND PLATOON TRAINING IN THE CLOSE COMBAT TACTICAL TRAINER (CCTT)

EXECUTIVE SUMMARY

Research Requirement:

Training needs have long existed for skills in tactically dealing with variations in communications capability which occur on actual dynamic battlefields. These training needs are becoming more critical as technological advancements lead to greatly increased electronic communications equipment capabilities and complexities. Enhanced capabilities can significantly increase combat power if decrements and limitations in capability are anticipated and skillfully handled. If not, then combat lethality, survivability, and tempo can suffer. This research is an initial effort to specify the needs for realistic communications training in mounted maneuver units and to identify strategies for meeting these needs.

Procedure:

A key problem is that perfect communications capability and quality is the usual environment for military training media and events, whether or not this is an accurate depiction of actual operations. The Close Combat Tactical Trainer (CCTT) will be the first training environment - be it live, virtual, or constructive - to purposefully vary electronics communications quality as it would be experienced on a real battlefield when conducting tactical maneuvers and engagements. The emerging CCTT environment was used, therefore, as a vehicle for examining warfighter tactical communications training needs and simulation-based strategies. Analyses were performed to first identify overall warfighter training needs and to then address those specific to Armor and Mechanized Infantry platoons equipped with conventional Single Channel, Ground/Air Radio Systems. Capabilities of initial CCTT production models to simulate realistic variations in communications quality were then evaluated in light of these needs.

Findings:

The overall training requirements in realistic tactical communications for warfighters were found to constitute a general model that effectively served as a basis for defining platoon training specifics. The platoon training specifics included training objectives and requirements for knowledge, skills, and attitudes. Structured training was identified as the most appropriate strategy for the CCTT, given its considerable

flexibility and anticipated training audiences. Structured training was outlined for crawl-walk-run stages meeting the specified communications training needs. These structured training vignettes, or tables, are intended to be used within the context of exercises designed to meet more general platoon training goals. Possible enhancements to CCTT's simulation of communications realism were also identified and their potential payoffs discussed.

Utilization of Findings:

Needs to augment training in warfighter communications on the future battlefield are being increasingly recognized. Findings from Advanced Warfighting Experiments investigating digitized battlefield issues underscore these training needs and give urgency to the search for solutions. This research effort initiates specification of these needs and how they can be met, to some degree at least, through the use of simulation training media like the CCTT. The report provides information needed for development of structured communications training in the CCTT and for articulating requirements for other training media and audiences.

SIMULATION-BASED COMMUNICATIONS REALISM AND PLATOON TRAINING IN THE CLOSE COMBAT TACTICAL TRAINER (CCTT)

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Introduction

This report concerns training in the tactical use of electronics equipment for transmitting and receiving communications on a dynamic battlefield. Technical aspects of the equipment under consideration include:

1. The forms of communication addressed here include not only voice but also alphanumeric messages, data (e.g., position, condition, status), and graphics.

2. While older communications equipment used an analog form of transmission, most newer military equipment transmit and receive in a digital form. The communications equipment of principal concern in this report are digital. Factors which can degrade communications quality will, however, similarly affect the transmissions of both digital and analog equipment.

3. These equipment items are connected by routes and linkages which often comprise discrete networks within an overall communications architecture. Major equipment components providing architectural structure to many Army units are members of the Army Tactical Command and Control System (ATCCS) (e.g., Advanced Field Artillery Tactical Data System). (See the primer produced by the U.S. Army Signal Center and School [1988] for more information on ATCCS and other electronic equipment. For an overview, see the recent Army Green Book [Association of the U.S. Army, 1996]). Parts of an architecture and the networks using them may vary from unit to unit due to differences in equipment resources and mission requirements. In any event, communication architectures are designed to support general communication requirements and, prior to a mission, discrete networks are tailored to support mission specific requirements (e.g., horizontally and vertically connecting Maneuver and Fire Support Systems to assure field artillery fires when and where needed for that mission). If needed during execution of a mission, subsequent changes to the networks may be feasible.

The quality of electronic communications transmissions and receptions is often not perfect in the real world - even though perfection is the environment normally provided for training media and events. Realistic communications can become degraded - sometimes devastatingly so - in terms of completeness, intelligibility, and correctness. See Garinther and Anderson (1996) for empirical data demonstrating the effects of degradation on soldier performance and Finley (1996) for discussions of this and other evidence. Examples of changing battlefield factors causing degradation include distance, terrain obstructions, weather, and enemy action. However, soldiers with

appropriate tactical training in dealing with these factors can often anticipate, avoid, minimize, or work-around degradation problems. This report addresses needs and strategies for training effective tactical use of electronic communications equipment. This report does not focus on either equipment operating procedures or technical electronics knowledge; information on these topics is available from other sources (e.g., Department of the Army [DA], 1995a; Helm, Mueller, and Cefaratti, 1995; Sanders and Elliott, 1996). The training needs of concern here are for skills in: recognizing current and anticipating future communications problems; identifying options; and implementing selected options.

Tactical communications training needs will be discussed within the context of the Close Combat Tactical Trainer (CCTT). The CCTT is a virtual training simulation currently under development by the U.S. Army. It is being designed to simulate certain realistic variations in communications quality as they would occur in dynamic battlefield maneuver operations. That is, the presence - or lack of - and quality of communications will vary realistically in response to a limited set of battlefield factors. For example, communications transmitted using line-of-sight (LOS) equipment will not be directly received whenever simulated intervening terrain features obstruct the LOS between sender and receiver. As another example, the loudness and clarity of voice communications will diminish as the simulated distance between sender and receiver approaches the radio equipment's maximum transmission range. The CCTT will be the first training medium ever to purposefully include realistic communications degradation of these types.

A long range goal of the CCTT is to serve platoon, company, and battalion collective training needs for heavy mounted tactical operations. The capabilities of the first CCTTs produced will be limited, however, to training platoons. This training will be further limited in that it will include vehicle simulators that have, as standard issue, communication equipment with digital voice capability only (e.g., M1A1 Abrams battle tank and other vehicles which are equipped with a voice-only Single Channel, Ground/Air Radio System [SINCGARS]). The term, "conventional" or "conventionally equipped," will be used throughout this report to designate the circumstance of being equipped with voice communications capability only.

Training for platoons with additional digital capabilities will follow with the introduction of the M1A2 tank simulator with its Inter-Vehicular Information System (IVIS) to the CCTT. Using SINCGARS as the means for transmission and reception, IVIS adds digital alphanumeric, data, and graphics features. Company and battalion training capabilities, and additional communications equipment (e.g., Mobile Subscriber Equipment) will be added in subsequent CCTT productions.

Overall tactical communications degradation training requirements and strategies are identified first for warfighters and their battle staffs in general. These are then tailored for platoon-level combatants with conventional communications and matched against the initial set of communications realism characteristics to be simulated in the CCTT. Recommendations are made as to which training requirements can be met given the characteristics of CCTT's realism, what training strategies could be adopted, and what enhancements of CCTT's communications realism should be considered.

Training needs regarding tactical communications realism identified in this first effort were found to fall into mission phase categories (e.g., planning, execution) and to be more or less generic across echelons. That is, while specific training needs within a particular mission phase might differ between echelons, the general training requirements appeared appropriate for most echelons. The conventional platoon training requirements and strategies addressed here are set in the context of the overall problem and generic tactical communications training categories. This sets the stage for addressing, at a later time, training requirements for platoons, and companies and battalions as well, with more sophisticated digital communications capabilities; and for matching these requirements to communications simulation capabilities offered by later versions of the CCTT.

Background

Warfighter Communications Realism Training Needs

Rapid advances in electronic communications technology are routinely touted. These advances are resulting in increased capabilities, speed, and ease of use. A major push in the Army is to take advantage of these advances by "digitizing the battlefield" for Force XXI, the vision of the Army for the 21st century ("Army Building Digital Foundation," 1994; Conway, 1995; Director of Information Systems for Command, Control, Communications, and Computers [C4], 1993). To the extent that digitizing battlefield communications leads to changes in tactics, techniques, and procedures then changes may be needed in what is trained and how it is trained.

A reality of the battlefield is that successful transmission and reception of communications - not to mention message completeness and validity - are not always certainties. There has never been a time, and probably never will be, when communications quality will be - under all conditions - 100% perfect. This is true even if equipment operating procedures, as in following correct and complete sequences, in and of themselves, are performed perfectly. Communications can be degraded by a number of factors other than incorrect procedures. Examples include terrain features, electronic interference, and enemy actions. Examples of the effects of these factors include

missing, delayed, or incorrect data; and inability to hear or decipher messages.

Such degradation can, of course, have serious consequences on the processes, products, and outcomes of military operations. Consequences can be even more serious if the military becomes too dependent on increased communication capabilities from battlefield digitization, creating pitfalls that could have been avoided. As noted, digitizing the battlefield may impose needs for training in new communications tactics, techniques, and procedures; what may be even more notable is training to avoid or handle disruptions in new communications capabilities.

This report addresses needs for tactical training with respect to degraded communications. Such needs have always existed but they usually have not been systematically addressed and met. These training needs are becoming increasingly critical, however, if we are not only to realize the advantages of electronics communications technology advances but also to avoid potential pitfalls.

Pitfalls are defined as "a danger or difficulty not easily anticipated or avoided" (Houghton Mifflin Company, 1994). Disruptions in communications quality can become pitfalls if soldiers assume optimal communications and operate without any expectation that failures to communicate could occur, or have no contingency plans when they do. It has often been observed by fellow exercise participants, for example, that many soldiers habitually use only certain communications assets and assume they will always work perfectly. When the capability of their favorite asset is lessened, they do not know how to react unless they have been specifically and recently trained in what to do. Anecdotal evidence cited by observer/controller subject matter experts suggests that, when soldiers perform in this manner, the consequences of communications degradation can be serious. This example of one factor, dependency, causing pitfalls, suggests soldiers need training in how to avoid communications degradation when possible and how to react if it does occur.

Occurrences and effects of degraded communications can be greatly mitigated if warfighters, their battle staffs, and those support personnel engaged in intensive data operations:

1. Have knowledgeable expectations regarding communications degradation;

2. Plan, prepare, and execute according to these expectations;

3. React effectively to unexpected degradation; and

4. Proactively monitor and control their communications in order to both maintain capability and availability, and to deny advantages to the opposing force (OPFOR).

All of the above require communications knowledge and skills that can be acquired and improved by education and training.

Again, the primary concern here is the training needs of warfighters and their battle staffs using communications equipment, whether directly or indirectly, as a part of planning, preparing, and executing tactical military missions. This report does not address the technical electronic and computer training provided to Signal soldiers serving in support roles. However, a Signal Officer is usually a battle staff member at echelons of battalion and above. One outcome of warfighters and other battle staff members acquiring knowledge and skills, like those listed above, might be more proactive and effective interaction with their Signal soldiers.

Given the foregoing, one would expect realistic communications degradation - that is, changes in communications quality and/or capability - to be frequently included as an aspect of tactical training. They are not. As Mueller (1991) notes, "The current training environment found in the Army expects (and has been conditioned to expect) uninterrupted communication support" (p. 89). Nearly perfect communications capability might not seem surprising for constructive and virtual simulated training environments; but this lack of realism is the norm for live training environments as well.

Perfect or nearly perfect communications are achieved in large live training exercises through careful analysis, assignment, location, installation, and set up of communications assets (equipment, relay nodes, frequencies, etc.) well before exercises begin. These are often done in accordance with the specifics of anticipated training missions and terrain movement patterns so as to <u>avoid</u> any problems. Further, backup equipment and pathways are made ready in case a communications problem should surface. OPFOR hostile actions against the unit's communications capabilities are limited, if played at all. The end result of these "precautions" is really a static, predictable battlefield from the communications standpoint - rather than a truly dynamic one. In smaller live exercises, communications quality is also usually high and there are no surprises. This is due to the fact that the range of movement is usually limited, and that this movement takes place on terrain that has been used repetitively. Hence, there are no unexpected problems.

Some analysts have begun to express concerns about communications training for warfighters and battle staffs. These expressions are often within the context of the "Information War" and address echelons at brigade and above (e.g., Cooper, 1995; Finley, 1996; Mueller, 1991). Although information warfare has long been a factor in combat, Gray (1993) underscored its increasing importance by stating: "The nature of warfare has changed dramatically. The combatant that wins the information war prevails ..." Army recognition of needs to better define

information operations, and to train them as well, has been indicated recently through publication of a TRADOC Pamphlet (DA, 1995b) and Field Manual (DA, 1996).

One research and development program addressing training needs for overall brigade-level command and control processes is including some effort directed towards communications transactions. This program is called Combined Arms Operations at Brigade Level Realistically Achieved through Simulation (COBRAS). It has been designed by the U.S. Army Research Institute (ARI) (Quinkert, 1996a). The COBRAS program will produce structured exercises that provide collective command and control training for the commander and up to 15 members of the battle staff at a time. (The topic of "structured" training will be discussed in detail later.) Included among the brigade staff trainees will be the Intelligence, Intelligence/Electronic Warfare Support, and Signal Officers. In addition to the larger exercises, smaller interactive vignettes will be developed to provide collective training for 2 to 10 staff officers, which may include the commander (Quinkert, 1996b). Although a small part of this larger program, this is a major step in tactical communications training. Unfortunately, however, none of the simulations to be used in playing the COBRAS exercises and vignettes provides systematic variations in communications quality. The simulations include live tactical operations centers (TOCs), and the constructive Battalion and Brigade Battle Simulation (BBS) and Janus simulation. The extent, therefore, to which the training scenarios can actually play changes in communications quality and capability remains to be determined.

There are, however, also needs for communications realism training at lower echelons. This became evident during training for and execution of the 1995 Advanced Warfighting Experiment (AWE) called Focused Dispatch (Elliott, Sanders, and Quinkert, 1996; Parry et al., 1996; Sanders and Elliott, 1996). The purpose of this AWE was to test the effects of digitization on a battalion task force.

Battalion members participating in the AWE were surprised at the degradation in communications quality they experienced when maneuvering on unfamiliar live terrain. This live experience reinforced their earlier surprise when they briefly trained in a virtual exercise where realistic variations in communications quality were simulated. One outcome of these surprises is that proactive use of and interaction with the Battalion Signal Officer (BSO) increased dramatically as training progressed in preparation for the AWE. This considerable level of positive interaction and collective involvement with BSOs has been reported, in the past, to be relatively rare. Recent observations of needs to improve, many suggesting a need for increased direct interaction with BSOs, have been documented recently by the Center for Army Lessons Learned (CALL) (1997a, 1997b, 1997c, 1997d).

The effects of experiences with communications realism on AWE participants argue favorably for introducing such training in the future. The virtual communications simulation was accomplished in this case by using a modification of the SINCGARS Radio Model (SRM). For descriptions of the original SRM, see Gonzalez, 1991; and Gonzalez, Pope, Tomlinson, and Van Hook, 1990. No version of the SRM has been used before in a training context or as a regular aspect of any other activity.

The capability of the first CCTT units produced will be limited to platoon training using conventional communications. This report, therefore, explores CCTT communications training for the conventionally equipped platoon. The circumstances, doctrine, and communication assets and requirements specific to a platoon limit the number of skills needed and the number of tasks requiring these skills. Platoon tasks and skills related to communications degradation do fall, nonetheless, into the generic phase categories appropriate for higher echelons: planning, preparation, and execution. For example, the scope required and time allowed for the platoon planning process, and the communications assets available, are very limited when compared to those of a battalion or brigade. However, platoon leaders and their crews do need - as do the higher echelons - to determine whether any degraded communications should be expected, if it can be avoided, and what contingency actions might be taken if it does take place. Under some circumstances, some form of communications mission rehearsal may also be appropriate as a part of the platoon's preparation phase.

Purpose and Description of the CCTT

Requirements for CCTT capabilities grew from the Army's experience with the Simulation Network (SIMNET). The initial concept for SIMNET was articulated in 1978 (Thorpe, 1978). Defense Advanced Research Projects Agency (DARPA) began developing SIMNET in 1983 to begin the exploration and demonstration of what new computer technologies might offer for collective tactical simulation (see Alluisi, 1991, and Cosby, 1995, for histories of SIMNET). While possible training capabilities were of considerable interest, SIMNET was not designed for the purpose of meeting training needs *per se* and the nature of training needs to be met were not specified in detail. The Armor School acquired a SIMNET prototype (circa late 1980s) to explore its training utility, and, along with other investigators, determined that it did appear to offer valuable cost and training benefits. Work to prepare a training device requirement (TDR) document for the CCTT based on SIMNET experience began during this period. Details from the recently approved TDR and other related documents will be discussed shortly.

The CCTT is to provide a medium for training and sustaining collective tactical tasks performed by Armor and Mechanized Infantry platoons, companies, and battalions in close combat.

The long range goal is to provide an environment for practicing skills and developing the synergism "across all the Battlefield Operating Systems (BOSs) of a battalion task force or cavalry squadron and their subordinate and supporting elements" (U.S. Army Armor Center and School, 1995, p. 1).

The CCTT is a computer driven system with simulator and emulator components that work interactively. These simulators and emulators are connected via a local area network using distributed interactive simulation (DIS) technology. The system's image generators and displays create a simulated battlefield and, when viewed by crewmen using the system, provide an illusion of moving and fighting over real terrain while operating the replicated vehicle and employing its weapon systems (U.S. Army Armor Center and School, 1995, p. 1).

A graphic depiction of a Company/Team fixed site configuration is provided in Figure 1. It consists of:

1. Combat vehicle simulators replicating vehicles found in close combat units (e.g., M1A1 and M1A2 Abrams Tank, M2A2 Bradley Fighting Vehicle); and

2. Emulator interfaces that control semiautomated vehicles and elements (e.g., dismounted infantry, mortar fire direction center, helicopters, higher order command and control, OPFOR).

Initial CCTT fielding will be limited to platoon training capabilities. Company and battalion training capabilities, and additional equipment simulations (e.g., Multiple Rocket Launch System, Mobile Subscriber Equipment) will be added later at selected sites as funding permits. The CCTT's initial fielding is expected to take place by the year 2000.

The CCTT is the first member of the Combined Arms Tactical Trainer (CATT) family of simulations to be developed. The overall purpose of CATT is to provide a capability to interactively network elements of a combined arms force in simulation, primarily for training (U.S. Army Armor Center and School, 1995, p. A-1). Development of CCTT will provide the foundation and many components for use in these future CATT members. The CATT will ultimately be comprised of several simulations which will be capable of operating jointly in a DIS environment. Potential CATT members include aviation, field artillery, engineering, military intelligence, and others.

CCTT's Overall Communications Training Capabilities

The Beginnings of an Evolution. During the time that the TDR for CCTT was being drafted, the digital SINCGARS was just beginning to be fielded. The concept of digitizing the battlefield on a grand scale was just beginning to evolve with,

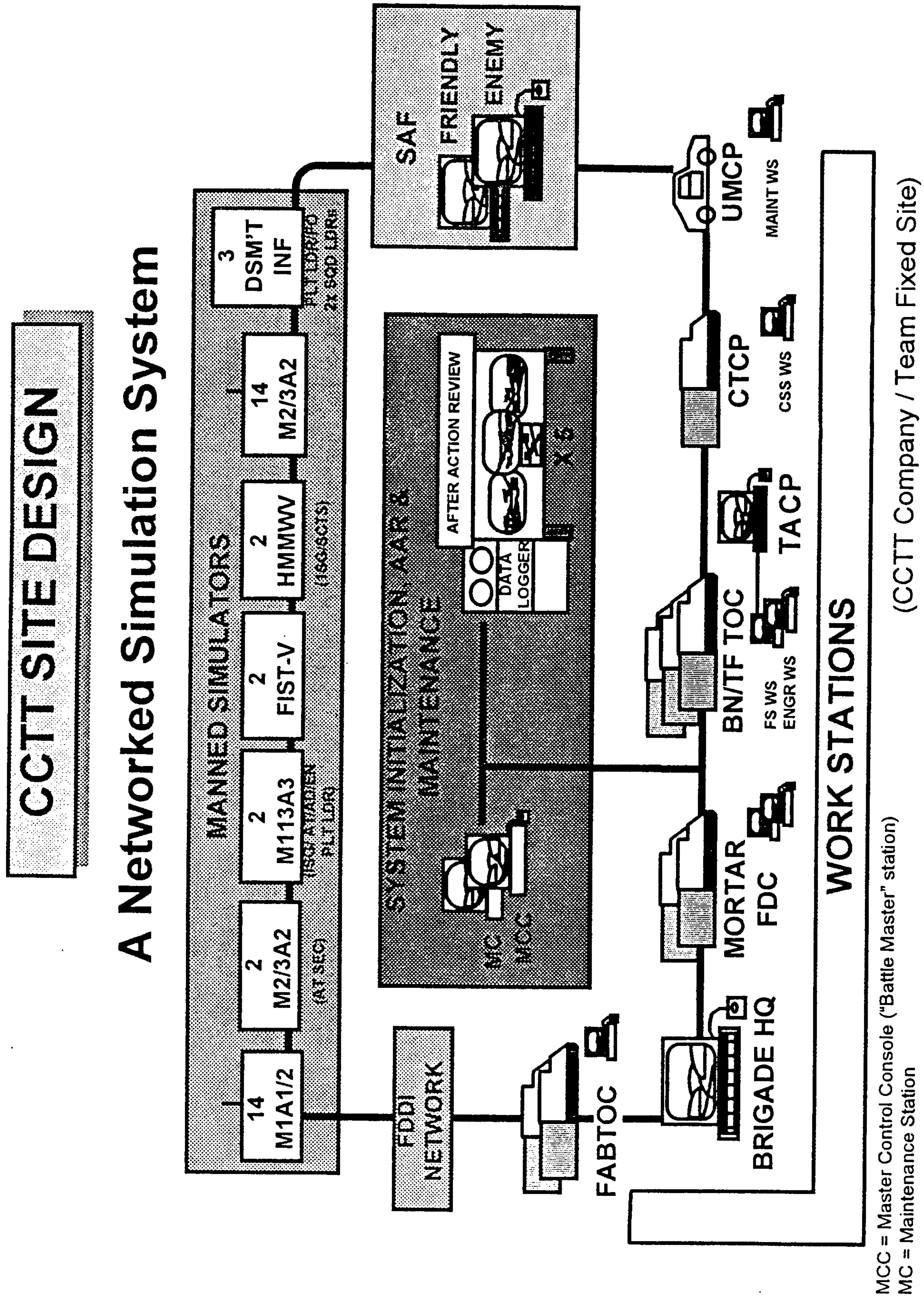

Figure 1. Design of CCTT Company/Team fixed site (Combined Arms Training Strategies Division, Armor School, 1995, p. C-3).

for example, the Sigma Star architecture and ATCCS (U.S. Army Signal Center and School, 1988). "Digitization" and "information warfare" were not yet a part of everyday conversation for most of the military. Today, in contrast, AWEs are being conducted to examine how to best use new and rapidly evolving digital communications capabilities in mounted warfare. The communications architecture tested in Focus Dispatch, the 1995 battalion AWE, is shown in Figure 2 to illustrate this point.

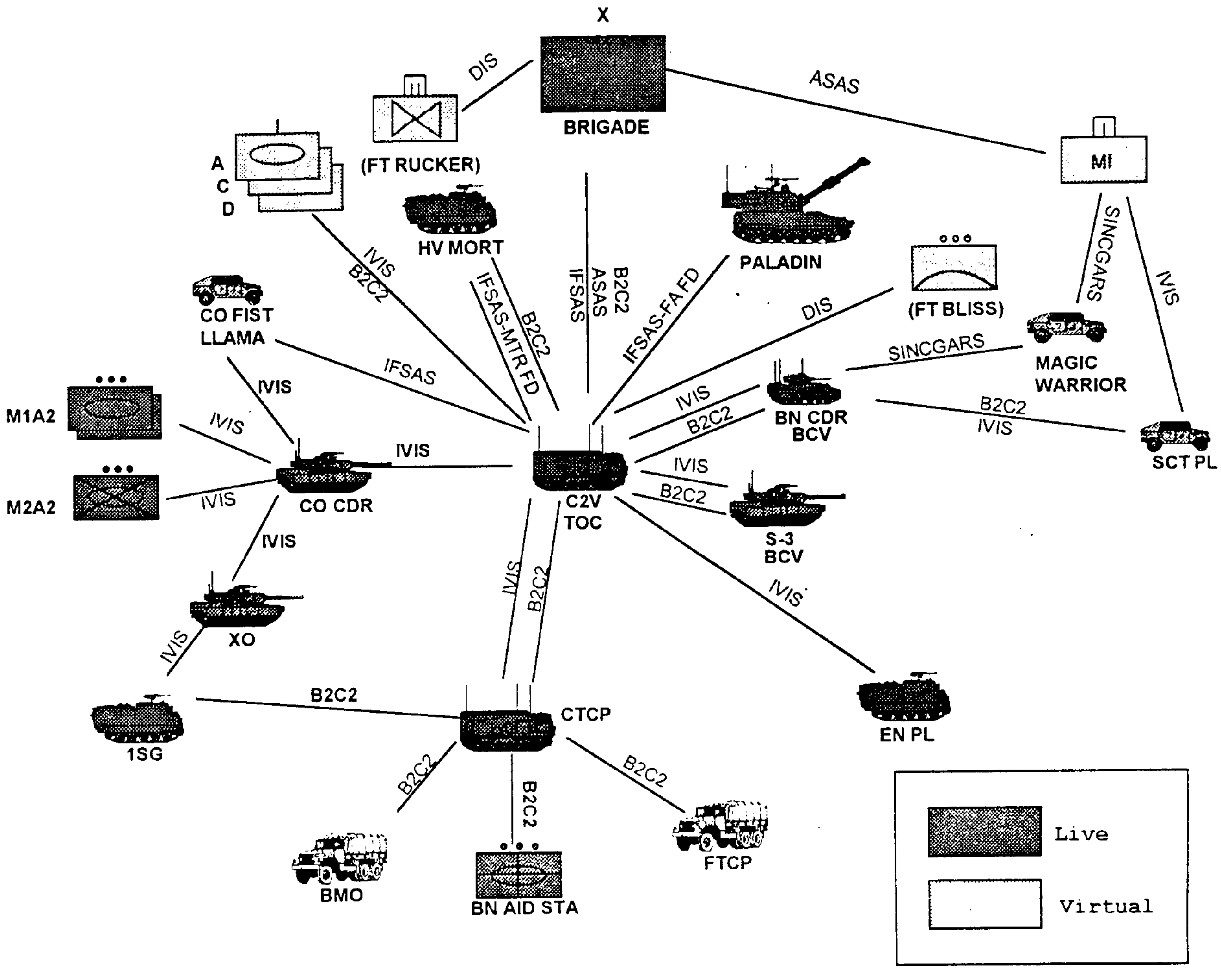

Figure 2. Equipment and communications linkages used in Focused Dispatch's live/virtual exercises (adapted from U.S. Army Armor School, 1995).

Given the foregoing, it is not surprising that, initially, no great attention was given to training for communications realism in CCTT. In fact, given the history of perfect communications in training environments (Mueller, 1991), it is surprising that any communications realism requirement was included in the original requirements documents. It is also clear from the original specification for building the CCTT that this was a new experience for materiel developers as well. The requirements and specification documentation presented next will demonstrate this point.

CCTT will be the first fielded training simulator to provide simulation of communications degradation when and as it might occur in a dynamic battlefield environment. This realism will be limited, initially at least, but it will exist and be a part of the training environment. This simulation capability - along with the ability to tailor training context features and interactivity between components - could provide soldiers with valuable experience in managing and dealing with tactical communications quality variations.

Requirements and Specification Documentation. The Training Device Requirement (TDR) (US Army Armor Center and School, 1991) was approved in 1991. It described the requirement for communications as:

> "Vehicular Simulator Modules...The system must replicate the Single Channel, Ground/Air Radio System's (SINCGARS) communications capabilities. It must allow the unit that is undergoing training to integrate its organic tactical operations center communications and wire communications schemes. The system must allow crewmen to use the combat vehicle crewman's helmet for communications, and must replicate the effects of interference, jamming, terrain obstructions, and distance on communications." (p. 4)

The original draft CCTT specification (Naval Training Systems Center, 1990), written in response to an earlier draft TDR (which had the same wording as above), stated:

> "...The ability to communicate shall be affected as it would in the real world by distance and obstructions where applicable in the exercise terrain...The radio configurations shall replicate the new SINCGARS series of radios...In addition to external communications via replicated radio, there shall be replication of external voice communication via land line simulation." (p. 49)

The most recent specification of CCTT communications (Loral Federal Systems, 1996) has grown to three pages. Two paragraphs extracted from this document illustrate the changes:

"Radio communication shall provide module-to-module, module to [tactical operations center] OC, module to SAF units, OC to higher headquarters and, OC to blue SAF units communications during real-time exercise operation. Communications shall only be possible when speaking on the same frequency or hopset, and shall be limited in the sense that a message can only be heard when in the listening position. During multiple transmissions on the same hopset (frequency hopping mode), a receiver shall receive the signal which arrives first at the receiver's location with adequate signal strength to be recognized and treat other signals as interfering signals. During multiple transmissions on the same frequency (single channel mode), a receiver shall receive the signal with the highest signal strength at the receiver's location or, if the signal strengths are the same, the transmission initiated first.

The ability to communicate and the quality of transmission (noise and signal level) shall be affected by distance, terrain, and interference in the gaming area. The quality of transmission shall be determined at each receiver's location relative to the transmitter location based upon the terrain database. The quality of transmission shall be based on a Frequency Modulation (FM) propagation model such as the Terrain Integrated Rough Earth Model (TIREM) developed by the Electromagnetic Compatibility Analysis Center (ECAC). The frequency and channel selection shall be provided at each position where external communication occurs in the operational vehicle and OC. The effects of CRYPTO and frequency hopping mosaics shall be simulated to include cryptographic related aural tones." (p. 84)

The original Operational Requirements Document (ORD), which translates the TDR into more operational terms, closely adhered to the TDR on the topic of communications. The most recent draft update to the ORD in 1995 (U.S. Army Armor Center and School, 1995), however, has increased the scope and realism features for communications. This CCTT ORD states:

"The system must provide voice and digital communications and replicate the Single Channel, Ground/Air Radio System's (SINCGARS) communications capabilities. It must allow the unit that is undergoing training to use its unique radio and digital communications scheme. Vehicle Simulator modules must allow crewmen to use combat vehicle crewman's helmet for communications. Simulated communications must *replicate the characteristics and effects of interference, terrain obstructions, electronic interference, jamming (when susceptible), and distance on communications and communications systems* [italics added]. The simulation will provide *replication of digital* [italics added] communications capabilities including specific systems such as Digital Message Device (DMD), Forward Entry Device (FED), Advanced Field Artillery Tactical Data System (AFATDS),

Inter-Vehicular Information System (IVIS), Army Battle Command System (ABCS), Force XXI Battle Command Brigade and Below (FBCB2) and Army Global Command and Control System (AGC2S). The simulation must replicate cellular communications using Mobile Subscriber Equipment (MSE)." (p. 4)

The Evolution Continues. The foregoing provides a picture of CCTT's evolution with respect to the simulation of communications realism. In gathering more recent information for this effort, it became clear that this is probably going to be a continuing evolution if funding is available. The research method was formulated, in part, on the basis of this insight.

Research Method

The goals of this effort were to identify training requirements and strategies for mounted platoons related to tactical communications realism that could be satisfied in the CCTT. The overall research method was one of gathering and analyzing information related to: communications realism training requirements; structured training strategies; and the specifics of CCTT's communications simulation capabilities. The need for information on the latter, CCTT specifics, derived from recognition of the extent to which CCTT's simulation capabilities have and may continue to evolve. It was realized that the research method had to go beyond identifying what, ideally, training was desirable and what strategies might best accomplish it. In addition, it also had to match these ideals to reality. In other words, the research had to try to identify CCTT's immediate capabilities to actually provide the specified training and then how these capabilities might evolve in the future.

General information regarding the training issue (communications realism) and training strategy to be used within the CCTT context (structured training) were already known and some documentation was available. This knowledge was relatively easy to update and apply as needed. The updating reviews are briefly described below. Using this knowledge, it was then possible to identify general training requirements and outline training strategies for use in the CCTT.

What was not so easy, however, was finding answers to detailed questions on CCTT specifics. These answers were needed to identify: (1) Which of these training requirements could be satisfied; and (2) To what extent the proposed training strategies could be implemented. The approach taken to find these answers are also described below.

Communications Realism Review

Knowledge of general communications realism training requirements and strategies was gained by the author from reviews of technical documentation (e.g., U.S. Army, 1990 and 1993); site

visits and discussions with subject matter experts; and through problem-solving activities with signal and warfighter personnel, training developers and providers, and fellow researchers. Literature searches were made through the databases of DTIC, NTIC, ERIC, MATRIS, and Psychological Abstracts. Very little literature was found on the topic of tactical communications realism. Two reports did, however, deal directly with the effects of communications degradation on armor crew performance and are, therefore, worth special note: Garinther and Anderson, 1996 and Whitaker and Peters, 1993. The knowledge base was expanded for this effort through review of more technical documentation (e.g., Cushman, 1989; C4 Architecture & Integration Division, 1993) and additional discussions. Some of the foregoing is described in more detail in Finley, 1993a, 1993b, and 1996.

Structured Training Review

To the extent training objectives are well defined and a systematic analysis process is followed (e.g., Systems Approach to Training [DA, 1988]), training can be more or less structured to meet the objectives. Compare, for example, exploratory learning (minimally structured) to lock-step programmed text (very structured). They both have some amount of structure and each has its own advantages; which is chosen depends, in part, on the training objectives.

Structured training, as applied in programs using virtual and constructive simulations, is defined as (Bessemer and Burnside, 1996):

> Systematic guided practice intended to master specific training objectives (tasks, conditions, and standards) in a set sequence that commonly increases [in] task performance difficulty. In addition to focusing on defined tasks or subtasks to be performed with controlled initiating cues and standard conditions, a key aspect of structured training is frequent performance feedback provided in after action reviews (AARs). (p. 1)

The same definition, but stated somewhat differently, is provided on the Force XXI Training Program Internet homepage:

> The deliberate design of training so that certain events will occur and cues will be provided to cause a specific training audience to perform particular (critical) tasks, subtasks, or actions.

This definition is presented within a graphic depiction which also includes AARs.

With the advent of virtual and constructive simulation-based training and their increasing capabilities to simulate alternative scenarios, environments, problematic events, etc. -

as in SIMNET - there is a temptation to use these capabilities creatively and on-the-spot. When this is done, the trainers and trainees are engaged in unstructured, or "free-play," exercises. This can be advantageous for trainees who are already well trained, but need an adaptive and challenging environment in order to acquire less common skills and/or more superior skill levels. Unstructured exercises may not be effective or efficient, however, for trainees with lesser skills and little time for training; or for enabling assessment of student performance levels and deficiencies against task performance standards (Bessemer and Burnside, 1996; Finley, Gainer, and Muckler, 1974). To maximize training benefits for these trainees, who will constitute the majority of the CCTT training audience, well structured training is the avenue of choice. Fortunately, it is true that, while virtual simulation-based training offers more free-play options, it also enables the application and enforcement of considerable structure to these options when desired. Further, structured training under these conditions, as compared to live training conditions for example, can be repeated much more exactly and as often as desired.

In preparation for applying the structured training strategy to the CCTT, extensive simulation-based structured training documentation was reviewed (e.g., BDM Federal, PRC, and Human Resources Research Organization (HumRRO), 1995; Campbell, Campbell, Sanders, Flynn, and Myers, 1995; Shlechter and Burnside, 1996). In addition, structured exercises were observed in SIMNET and discussions were held with developers of new structured training programs (e.g., Quinkert, 1996a, 1996b).

Questions Regarding CCTT's Communications Simulation Capabilities

Some questions on CCTT's communications realism simulation capabilities were not answered by review of initially available requirements and specification documentation. Reasons for this lack of information and/or ambiguity of presentation stem from factors often found in large system development programs. These factors include:

1. The details of system design and use evolve over time;

2. Initial plans include plans for future product improvement where system fielding is expected to occur in stages of advancing capability; and

3. If preplanned product improvement (P3I) is a part of the overall system development plan then there may be ongoing or anticipated research programs supporting the development of future capabilities; the outcomes of research are never certain.

Certainly the details of CCTT's design and use have evolved over time in several areas. This would be expected in the communications area, given that: these types of communications realism characteristics have not been simulated before, and they

have been accompanied by rapid technology advances and applications. Further, the CCTT is a P3I effort, progressing from an initial platoon training capability to a much more complex battalion capability with, potentially, additional simulation capabilities as well. Finally, some specifics of future CCTT capabilities will depend on the outcomes of ongoing research.

The unanswered questions regarding CCTT's communications realism simulation characteristics included:

1. Question One: Will realistic communications degradation apply only to SINCGARS; or to some of the other simulated equipment items and entities as well (e.g., AN/VRC-47 radio, MSE, TOC, OPFOR); or to all equipment items and entities?

The requirements and specification statements do not explicitly restrict communications realism to the SINCGARS (see the quotations from these materials presented earlier). However, the combination of their placement within surrounding text and nonspecificity regarding simulation realism characteristics in sections describing other CCTT components does not make it clear whether realistic degradation applies only to SINCGARS or to other equipment and work stations as well. Considering the novelty of endeavor, and rapid advances in technology and utilization concepts, answers to Question One are not immediately self evident.

2. Question Two: If the answer to the above question is "The intent is to have simulated realistic communications degradation in the ultimate, objective CCTT for all or some of the components, linkages, and conditions where it would validly occur," then the next question is: How will this realism evolve?

As noted before, the CCTT will be fielded in stages, progressively adding entities and capabilities. What is not clear, for example, is whether - in the first conventional platoon fielding - SINCGARS transmissions between a platoon trainee's tank and the company commander will be degraded when appropriate, given simulated distance and terrain conditions. The answer to this question cannot be assumed to be "yes" where the focus is on platoon training as conducted in the initial platoon CCTT fielding. In this case, the company commander will probably not be positioned in a simulator and interacting with the terrain, but, rather, in an outside work area. As another example, it is not clear whether or not - when the M1A2 with its IVIS is added to the platoon capability - potential IVIS/SINCGARS capacity problems will be simulated.

The issues are comparatively limited and simple for the platoon. As one moves up to company and battalion level capabilities, however, the number of questions that need to be answered will grow in number. Unless, of course, the answer to the first question is simply: "There is no expectation of ever

simulating realistic communications degradation for anything other than SINCGARS and then only for transmissions among the principal trainees (e.g., transmissions among member tanks at platoon, company, and battalion echelons)."

3. Question Three: Exactly what realism characteristics will be simulated for which communications equipment items, entities, and linkages?

The answers to this question will determine what about communications degradation realism can be explicitly and directly trained in the CCTT. The question is akin to that of, "What realism characteristics will be simulated for the terrain"? In the case of terrain, it is anticipated that the training benefits would be considerable if a dynamic interactive terrain database could be made a part of the CCTT. The same expectation should hold true for the communications world.

The materiel developer's 1990 CCTT Specification (Naval Training Systems Center, 1990), and the proponent's 1988 TDR (U.S. Army Armor Center and School, 1988) and 1995 ORD (U.S. Army Armor Center and School, 1995) were compared with respect to the realism features they each specified. (As noted above, however, - whatever the features - it is unclear as to whether these features are intended for equipment items other than SINCGARS and/or for simulation players who are not positioned within a simulator but do have a communications linkage with them.) The specified features include distance, terrain obstruction, jamming, electronic interference, and interference. It is not clear from the documentation whether the "interference" requirements in the TDR and ORD refer to positional aspect interference or positional electronic interference or both. Both of these are usually experienced, if at all, when the positions are closely situated. Positional electronic interference is caused when the location and position of a vehicle or work station is such that its transmissions interfere with the communications of others or its own capability to transmit and receive is electronically interfered with by others. Positional aspect interference can result from one vehicle obstructing the LOS between two other vehicles or when there is a poor equipment LOS between two vehicles. An example of the latter occurs when a lead tank moves over a steep hill crest and begins descent while other platoon members are still ascending the hill.

A portrayal of the specified features is presented in Table 1. It can be seen that, from the documentation, it is not clear if or at what fielding stage the features of jamming, interference, and electronic interference will come into existence. Other features that could degrade communications have not been included in these documents. Examples of this, channel capacity and OPFOR aggressive action, are shown with empty cells in Table 1 to call attention to this incomplete coverage.

Table 1. Communications realism features identified in CCTT TDR, ORD, and specification documents, and two features that are not.

REALISM FEATURES	REFERENCES 1991 TDR	1995 ORD	1996 Spec
Distance	X	X	X
Terrain Obstructions	X	X	X
Jamming	X	X	-
Interference	X	X	-
Electronic Interference	-	X	-
Channel Capacity	-	-	-
OPFOR Aggression	-	-	-

4. Question Four: Can we turn degradation realism off?

This is an especially important question. If the answer is, "no," this would have a considerable and negative impact on what can be done in terms of training strategies. If the answer is, "Yes and, not only that, we can turn degradation features off selectively," this would have a very positive impact. This impact will become evident when the proposed strategies are described and discussed later.

How The Questions Were Addressed

Efforts to analyze these questions led to development of three tools: The CCTT Communications Matrix, a legend key for entries into the Matrix cells, and a Matrix cell contents work sheet. These tools were used in obtaining information needed to answer the four questions. They are described below and presented in Appendices B, C, and D.

The tools were developed to be applicable to not only the conventionally equipped platoon but also to subsequent CCTT versions with more sophisticated communications and higher echelon capabilities. Their application will be further discussed later as front end analysis (FEA) tools that could be used in implementing training requirements. At this time, these tools are draft instruments that were used informally by the author. If they have a future life, it is anticipated that their role would be that of aiding FEAs by training developers and designers. In their present form, they are much too unwieldy for use by, for example, operational personnel (e.g., unit trainers) and are not tailored for their purposes.

These tools were used in interviews with Signal Officers stationed at Fort Knox; CCTT Project Office personnel; and the system architect engineer for Project Manager (PM) CATT Command,

Control, Communications, Computers, and Intelligence (C4I). They were also used in reviewing additional and updated documentation that these persons provided. The tools provided a means for focusing discussions, and in guiding searches for additional documentation. The results of these interviews are described later in the section on CCTT simulation capabilities.

The following describes how these tools can be used and the type of information provided:

CCTT Communications Matrix (Appendix B). The purpose of the Matrix is to aid identification of what communications capabilities exist and the entities with which they are associated. Once the Matrix cells have been identified then information regarding the extent and nature of realism simulation can be sought on those cells of interest. Depending on the analyst's purpose, it may be desirable to check those Matrix cells which represent the real world as well as the simulation under consideration. With proper notation, these dual entries can facilitate comparisons that are useful to training developers when they are making decisions regarding training strategies. The Matrix lists simulators and work stations along one axis. For this analysis of the CCTT, these entities are grouped into three categories: SAFOR, Operations Center, and Simulator Modules. The second axis lists those communications equipment items which are or could be in the CCTT. "Communications Equipment," in this context, is any equipment item which, as a part of its functional usage, transmits and/or receives data and information in electronic form. An example of Matrix usage is that one of the Matrix cells checked in the present application was: "Simulator Module M1/M1A1" x "SINCGARS."

Instructions and Legend for Matrix Cell Contents Worksheet (Appendix C). Numbers from 1 to 6 are listed, with each number representing a descriptor. The choice of number, or descriptor, provides a rough indication of the extent to which a Matrix cell - representing a communications equipment item in association with a simulator module or work station - is simulated. The responses range from 0 = "Not present at all" to 3 = "Physically present and operational, but nonfunctional" to 6 = "Functional with realistic/deterministic variations due to ..." The use of numerical values is a convenience that, at best, translates into an approximate rank order. All three of the numbers 4, 5, and 6, or some subset thereof, can be selected for a single Matrix cell when appropriate. The numbers 3 and 4 can also be assigned to a single Matrix cell. Matrix cells receiving numerical assignments of 0 - 4, and none higher, require no further analysis with this tool. This is because these numbers indicate that no realistic variations in communications quality are simulated. The analyst then reviews Matrix cells receiving number assignments of 5 and/or 6 in an attempt to specify the realism characteristics of the simulation for that cell (e.g., are voice fading and/or clipping simulated in SINCGARS receptions as appropriate?). Fourteen factors affecting communications are listed to assist

this review. The prespecified factors range from A = "Distance" to M = "BLUEFOR can play logistics actions and delays in replacing/installing relay nodes," with N = "Other." Several notes are appended which either provide explanatory information or remind the analyst to obtain particulars (e.g., names and phone numbers of persons interviewed). The Matrix cell provided as an example above, "Simulator Module M1/M1A1" x "SINCGARS," can now be examined to provide an example of using the Legend Key. This example would have at least the following entries:

- Numerical values 4c ("Can choose either mode of frequency hopping") and 6 ("Functional with realistic/deterministic variations due to:";

- Factor A ("Distance") would be checked with a notation of "N" ("Realistic response cannot be turned off") and a description stating that there is "Fading due to distance and clipping due to frequency hopping"; and

- Factor B ("Terrain and/or objects") would be checked with a notation of "N" and a description stating, "Both; a function of size, altitude, and location in computation grid."

Factor C ("Dead space") would not be checked as this characteristic is not simulated by the CCTT, even though it is a real occurrence under certain terrain and meteorological conditions.

Matrix Cell Contents Worksheet (Appendix D). Every analyst has formats and media which that person finds most useful for cataloging information. Appendix D is one possible approach.

Results

Training Requirements and Strategies

A CCTT requirements document provides an overall training goal of practicing skills and then developing synergism "across all the Battlefield Operating Systems (BOSs) of a battalion task force or cavalry squadron and their subordinate and supporting elements" (U.S. Army Armor Center and School, 1995, p. 1). More specific training requirements and strategies for the tactical communications skills component were identified through analysis of information collected using the research method described in the previous section. Again, information sources included reviews of task descriptions and training packages, observations of SIMNET and field training exercises, and discussions with subject matter experts.

Individual and collective communications tasks were found in reviews of task lists and some training packages. As anticipated, however, possibilities of communications quality variations during tactical operations were generally not made explicit. In some cases, tasks concerned other issues (e.g.,

land navigation); potential communications problems could be identified only through analysis regarding that potential. As perhaps corollaries to this are these findings: (1) Signal subject matter experts (SMEs) report that realistic communications degradation is generally excluded from field training and (2) SIMNET and other virtual simulations (e.g., Conduct of Fire Trainer, Tank Driver Trainer) do not include capabilities to simulate realistic communications degradation. Examples of individual tasks listed in the Career Management Field (CMF) 19 Master Task List (U.S. Army Armor Center, 1996) with implications for realistic communications concerns based on the tactical situation include:

1. Implement methods to extend range of radio communication

2. Recognize electronic countermeasures (ECM) and implement electronic counter-countermeasures (ECCM)

3. Operate SINCGARS frequency hopping (FH) (net members)

4. Identify topographic symbols on a military map

5. Identify terrain features on a military map, and

6. Analyze terrain

The focus of other communications tasks found in the documentation appeared to be more on procedural knowledge and skills. Examples of the latter include: "Inspect an installed OE-254/GRC antenna" and "Read a message." The first three tasks above were also listed in the Tank Platoon Mission Training Plan (MTP) as a part of a collective task, Employ Operations Security Measures (U.S. Army Armor Center and School, 1996, p. C-16).

The Tank Platoon MTP also describes these leader training tools to assist in preparing for situational and other collective training exercises: map exercise (MAPEX); tactical exercise without troops (TEWT) or terrain walk, and communication exercise (COMEX). Communication aspects of these leader preparation exercises were limited to enabling "leaders to set up and test communication systems and review voice and digital transmission procedures" (U.S. Army Armor Center and School, 1996, p. 4-4). Terrain analyses, and inspection and use of maps (the last three tasks above), appear to be directed towards land navigation questions of movement support, and cover and concealment.

Data such as described above and that obtained through use of the research tools (Appendices B - D) were first outlined from a broad perspective, giving consideration to soldiers in positions ranging from command and battle staff members to tank commanders. The analysis was then narrowed to focus on the platoon. It was found that the descriptions of training requirements developed from the broad perspective were generally applicable at the platoon level as well. As might be expected,

however, comparatively minimal requirements for platoon training in communications realism were identified through analysis of these data. This finding was a function of content provided by descriptions of: what is done by the platoon, how they do it, the communications assets available to them, and requirements for using these assets.

The results were organized by the following areas: training goals, objectives, and knowledge, skill, and *attitude* (*KSA*) requirements (see next paragraph for note regarding *KSAs*); training strategies; training frequency and duration considerations; identification of training contexts; and training development and implementation requirements. These are each described in the sections that follow.

(NOTE: a common meaning of the "A" in KSAs is "abilities." In this report, however, the "A" will always, and very intentionally, stand for "*attitudes.*" An italicized *KSA* will be used henceforth as a reminder of this difference. The basis for this position is that "ability" has many definitions, depending on the extent to which "ability" is understood to mean acquired versus inherent versus native. From the training standpoint, one can teach attitudes, like safety, but not native abilities; and the distinction between knowledge and skills versus acquired abilities is often a tenuous one.)

Platoon Training Goals; Objectives; and Knowledge, Skill, and Attitude Requirements. Training goals are presented first, followed by training objectives. The *KSA*s are presented last.

Training goals. Warfighter communications realism training needs were discussed in the Background section. To facilitate discussion here, the goals that were identified are repeated:

1. Have knowledgeable expectations regarding communications degradation;

2. Plan, prepare, and execute according to these expectations;

3. React effectively to unexpected degradation; and

4. Proactively monitor and control their communications in order to maintain both capability and availability, and to deny advantages to the OPFOR.

Training objectives. With these goals in mind, I identified platoon training objectives using the information gained from the reviews described earlier. Seven objectives were identified, where the overall standard for each one is to know how to perform the associated tasks well and to perform them as a matter of routine. These objectives should be considered as ones that either complement or are in addition to those already represented by individual and collective tasks in current task and training

documentation (e.g., Objectives 6 and 7 complement the ECM, ECCM, and SINCGARS tasks from the CMF 19 Master Task List discussed earlier). The seven objectives are:

1. Perform a pre-mission communications degradation analysis.

2. Develop a communications tactics course of action (COA) and contingency plans addressing potential communications problems.

3. Perform a mission communications rehearsal.

4. Effectively react to unexpected degradation during mission planning, preparation, and execution.

5. Maintain radio discipline.

6. Know the conditions requiring frequency hopping, understand the relationships of frequency hopping with communications security (COMSEC) and jamming, and use frequency hopping when it is appropriate. (NOTE: Frequency hopping is a capability provided by digital technology. It is the very rapid random changing from one frequency channel to another during transmission of a message.)

7. Exercise awareness of the possibility of OPFOR deception regarding frequency/channel quality and any other possible OPFOR deception actions. The assets of the platoon are such that certainty of such OPFOR actions is not possible, but such awareness should reinforce achievement of objectives 5 and 6.

More precise standards can be developed for each of these once the exact procedures to be followed and the conditions under which the procedures apply have been defined by SMEs. For example, it needs to be decided what would constitute the "pre-mission communications degradation analysis" to be conducted by the platoon and what, if any, variations may be needed under particular conditions. Similarly, responsibilities need to be assigned for performance of tasks to accomplish these objectives. The platoon leader, platoon sergeant, or both, might have primary responsibilities for the accomplishment of all seven objectives; but other platoon members should probably have some knowledge and skills related to at least Objectives 3, 4, 5, and 6.

Knowledge, skill, and attitude requirements. These objectives were then analyzed to identify *KSAs*, the most detailed level of training requirement defined in this report, needed to reach these objectives. The *KSA* requirements fall into four groups:

1. Signal Knowledge: Factors and conditions affecting communications quality (e.g., transmission range as a function of range extension assets available and ground composition; jamming; LOS; frequency hopping); the nature of their effects on

transmitting and receiving; alternative modes of communication; and information on how to avoid informing and perhaps even deceive the OPFOR.

2. Technical and Tactical Procedures: Equipment and standard operating procedures supporting individual crew member communications responsibilities and requirements for backup in the case of equipment or member loss; vertical and horizontal interactions, which, in the case of a platoon, means communicating with: Other tanks in the platoon (and avoiding position and electronic interference in the process), the company commander, and, possibly, as communications contingency options, the TOC, Fire Support Element, or other company commanders; and the communications architecture providing these options. (Communications equipment procedural knowledge and operating skills - currently limited to SINCGARS in the case of a platoon - are prerequisites for entry into CCTT training. This will be discussed later.)

3. Communications Discipline: Use communications equipment only as necessary and as efficiently (e.g., use strict protocols) as possible. Radio chatter, for example, can give position and other information to the OPFOR, and may prevent transmission/reception of critical information to the platoon. While communications discipline can decrease the amount of information provided to the OPFOR, it can also, overall, lessen soldier and system overload, interference with operations at other tactical locations, and facilitate information management. Communications discipline is critical with both voice and digital systems, but it may be more complicated in platoons employing SINCGARS with IVIS capability. Here, experience is not yet sufficient to entirely resolve many questions as to when voice or digital data burst is best - even when the need to communicate, in and of itself, seems clear.

4. Application of *KSA*s 1 - 3 to Mission Processes and Tasks:

a. Planning Phase: perform an analysis of the platoon operations order (OPORD) to determine what, if any, communications problems might occur, under what conditions, and at what point(s) in the mission. Further detail and fine tune the platoon's COA to minimize or otherwise deal with the problems.

b. Preparation Phase: Conduct a mission communications rehearsal. Rehearse standard communications operating procedures, backup and other contingency procedures, and the communications COA planned for mission execution.

c. Execution Phase: Implement procedures and discipline. Validate COA expectations and modify COA as required and feasible. Proactively monitor and control, acquiring additional knowledge as needed and feasible.

d. After Action Review(AAR): Use the AAR process to gain feedback on adequacy of actions with regard to communications and to answer unresolved questions.

The relationships between the training goals and objectives, that is, which objectives lead towards which goals, are depicted in Table 2. Like relationships between *KSA*s and objectives are depicted in Table 3.

Table 2. Training objectives to meet the tactical communications realism performance goals.

	GOALS			
TRAINING OBJECTIVES	Know What to Expect	Plan, Prep, & Execute Accordingly	React to Unexpect	Proactive Monitor & Control
Pre-Mission Anal	X	X	X	
COA & Cont Plans	X	X	X	X
Rehearse Mission		X	X	
React to Unexpect	X		X	
Radio Discipline	X	X		X
Frequency Hopping	X	X	X	X
OPFOR Awareness	X	X		X

Table 3. Knowledge, skills, and attitudes to meet the tactical communications realism training objectives.

	KSA REQUIREMENTS			
TRAINING OBJECTIVES	Signal Knowledge	Technical & Tactical Procedures	Commo Discipline	Apply to Mission Proc&Task
Pre-Mission Anal	X			X
COA & Cont Plans	X	X		X
Rehearse Mission	X	X	X	X
React to Unexpect	X	X		X
Radio Discipline	X		X	X
Frequency Hopping	X	X		X
OPFOR Awareness	X		X	X

Training Strategies. The first training strategy issue is, "What should the prerequisites be for entering into training on the CCTT?" The subsequent strategies discussed are ones for skill acquisition and sustainment.

Entry level knowledge and skills for CCTT training. Soldiers will benefit more from CCTT training if, before attempting to participate in CCTT exercises, they have already acquired: Expectations regarding the "real" world of tactical communication; an appreciation that there are ways to deal with some communications degradation; and the basic procedural skills needed to operate communications equipment. The sophistication of CCTT's communications realism and other simulation capabilities are designed for training tactical skills needed to effectively apply the foregoing knowledge and skills under dynamic and challenging battlefield conditions. However, less complex training media with a more limited focus are better suited and cost effective for providing initial understanding of concepts related to communications degradation and basic procedural skills. It is suggested, therefore, that possession of basic levels, at least, of knowledge and skills be specified as prerequisites for entry into CCTT training. These could include:

1. Knowledge regarding causes, effects, and possible contingency actions for communications degradation;

2. Understanding of the concept, purpose, and use of unit communications architectures; and

3. Communications equipment procedural skills.

The foregoing is said with the understanding that, at present, communications equipment procedural skills (item #3) is the only item that is already a part of training regimens leading up to the use of equipment simulators or actual equipment. It has been observed that this procedural training is not only essential but also needs to be intensified and sustained (Parry et al., 1996). Items 1 and 2 are not included in current training regimens and, therefore, would have to be introduced to those regimens leading to use of CCTT. Experiences gained from the Focused Dispatch AWE indicate that an effort to introduce education covering items #1 and #2 prior to conducting maneuver training exercises would be well advised (Elliott, Sanders, and Quinkert, 1996; Parry et al., 1996; Sanders and Elliott, 1996).

Having this entry level knowledge and communications equipment procedural skills will facilitate not only development of tactical communication realism *KSA*s, but also most other tactical skills being trained in the CCTT. A major reason for this is, without having these entry level understandings and capabilities, the communications realism feature is likely to act as a training disrupter. While research has shown that realistic

disruption can increase transfer of training to the job - it has also been shown that the price to be paid is an increase in the time it takes to reach task performance standards during the training period (Magill and Hall, 1990). In short, it is not that these entry level understandings and capabilities are an absolute requirement; rather, it is that the price to be paid for not having them must be recognized.

Skill acquisition strategy. Tactical communications skills, like many others, could be trained effectively and efficiently through use of a strategy where exercises are both structured and progressive, using crawl-walk-run options (Campbell, Campbell, Sanders, Flynn, and Myers, 1995). This strategy might be integrated into CCTT platoon exercises developed and structured for the primary purpose of training tactical maneuver skills. Such exercises would provide the context within which tactical communications skills could be trained as well, perhaps as parts of vignettes or tables within platoon exercises developed to meet larger objectives (e.g., movement to contact, deliberate attack). If integrated properly, this would not only meet the unit's needs for training on other tactical tasks but also tactical communications tasks.

The Simulation-Based Multiechelon Training Program for Armor Units (SIMUTA) platoon exercises were developed with crawl-walk-run versions. See BDM Federal, PRC, and HumRRO (1995) for examples of exercises and training support packages (TSPs) developed under this program. The SIMUTA structured crawl-walk-run exercises were developed to train tactical maneuver tasks using SIMNET. No structure was included in these exercises to impose communications degradation incidents under selected conditions as needed to expose trainees to communications reality or to train appropriate proactive or reactive responses. This is because SIMNET has no capability to simulate communications realism.

The platoon communications crawl-walk-run stages will be described in terms of tasks to be performed and conditions of performance; these and the training purposes are derived from the contents of Tables 2 and 3. They could, if desired, take place within the context of exercises for the mission phases of planning, preparation, and execution.

It should be noted that all structured training exercises developed for SIMNET, CCTT's predecessor, have been for the execution phase only (e.g., executing a movement to contact, executing a deliberate attack). This has been due, primarily, to resource constraints and consideration of training priorities and efficiencies. Current SIMNET practice is to provide operations orders, overlays, and other support materials for selected execution exercises to units prior to their arrival at SIMNET. This is done in sufficient time to allow unit personnel to practice planning and preparation tasks before hand, using the context of anticipated SIMNET execution exercises.

If execution task training is emphasized in CCTT as well, then planning and preparation communications task training might be handled according to the SIMNET model. Platoon communications planning and preparation tasks might be trained at home station, prior to arrival, or in a facility located near the CCTT training site. To the extent reasonable, these tasks could be integrated into the training for other planning and preparation tasks.

A description of possible contents for a platoon communications crawl-walk-run training program is presented below. A later section will address the steps that a training developer might take to implement these requirements and produce fully developed vignettes, tables, and TSPs.

Taking a requirements approach, these stages are described in terms of what might be desirable rather than the communications simulation capabilities the CCTT will possess, initially or ultimately. The CCTT's initial capabilities will be discussed and compared to what is desirable later. The reader should not expect that all suggestions made here can be implemented on the first issue of the CCTT (platoon with voice-only capability), or even later issues. Further, while the capability to simulate some aspects of communications realism may be desirable, it may not be technically feasible or cost effective to do so.

The following skill acquisition strategy is presented with the assumption that trainees have already acquired the entry level communications knowledge and equipment procedure skills described above. The strategy includes communications planning and preparation tasks, but does not assume that these tasks will necessarily be trained within the CCTT facility. Given these considerations, a CCTT platoon crawl-walk-run communications training strategy could look like:

1. Communications Crawl Level Training: 100% perfect communications (i.e., unrealistic) should be used initially - not only to start the crawl stage of communications training - but also to avoid disrupting training with respect to other collective maneuver tasks (e.g., maintain a wedge, or other formations, in movement to contact). This is especially true if the trainees are in a crawl stage with regard to these other tasks as well. The communications crawl stage could consist of analyzing the unit's communications architecture for that mission and those pathways within it available to the platoon; and then using this knowledge in:

a. Performing a mission rehearsal based on the unit's standard communications procedures and routings, and any alternatives available at the platoon level;

b. Performing standard communications procedures during mission execution; and

c. Performing alternative communications procedures and routings, as appropriate, during mission execution. Communications tables or vignettes within larger exercises may be placed where conditions and cues will cause trainees to select alternative procedures/routings.

If the CCTT does not have an "off" switch for communications realism, then crawl exercises for both communications and maneuver skill acquisition must be carefully developed with regard to terrain obstructions or other factors simulated to affect communications quality. These exercises must be designed in such a way as to minimize or eliminate any chance of communications degradation. If exercises are developed so as to minimize communications degradation, then additional planning tasks can and/or should be included as preludes to mission execution:

d. Review the OPORD for potential communications degradation points in the mission; and

e. Identify any possible workarounds.

2. Communications Walk Level Training: Purposefully design walk exercises such that communications degradation will occur realistically from natural causes. All five tasks identified for the foregoing crawl stage would be performed in the walk stage as well; the last two tasks become especially appropriate in the walk-level context. Tasks pertinent to maintaining radio discipline and frequency hopping should be added as well. The purposes are to provide training in:

a. Using knowledge of conditions when degradation can be expected and how to avoid it if possible;

b. Planning and then implementing possible contingency actions; and

c. Not allowing unavoidable communications degradation to disrupt mission execution.

Communications walk exercises should be designed to include progressively difficult communications conditions due to natural causes. This would entail selection of terrain features, weather, and other natural conditions that cause problems; creation of mission scenarios situating the platoon so as to ensure communications problems resulting from these conditions and, also, extended distances between sites; and development of OPORD and overlay TSP materials which allow trainees, using appropriate analysis techniques, to identify potential problems and solutions.

3. Communications Run Level Training: Employ OPFOR proactive/preplanned events or reactive events that degrade

friendly, or Blue Force (BLUFOR), communications and/or take advantage of engagement opportunities afforded by poor BLUFOR communications behaviors. The purposes of these events are to provide training in:

a. Effectively reacting to unexpected degradation during mission execution.

b. Maintaining radio discipline.

c. Knowing those conditions requiring frequency hopping; understanding relationships between frequency hopping, communications security (COMSEC), and jamming; and using frequency hopping when appropriate.

d. Being aware that actions by the OPFOR may be causing apparent frequency/channel quality differences and perhaps other anomalies as well - even though the platoon itself is unable to identify these as OPFOR deceptions.

Preplanned events would be designed into run-level exercises and TSP materials. Examples include use of jamming at points in the exercise where BLUFOR might be less inclined or able to use frequency hopping; and selective destruction of part(s) of the communications architecture (e.g., destruction of a SINCGARS relay node or a Company Commander's vehicle) to force trainee use of alternative communications routings.

Reactive events (for which guidance should be included in TSPs) would be actions taken by the OPFOR in response to BLUFOR communications behaviors that could be costly if they took place during actual combat. The primary purpose of OPFOR reactive events is to create exercise situations that, while they may have immediate corrective effects on the trainees, can certainly be used during After Action Reviews to make teaching points. Examples of communications behaviors needing correction include poor radio discipline (e.g., unnecessary radio chatter) and failure to use frequency-hopping when it would be dangerous not to do so. Possible OPFOR actions might include: jamming; directing firepower (e.g., artillery) towards errant BLUFOR trainees; and using information gained from BLUFOR communications to better position and maneuver the OPFOR.

Skill sustainment strategy. Refresher training will, most likely, be needed to assure that soldiers maintain communications security as a matter of routine and are ready to deal with challenges resulting from the effects of battlefield reality on communications quality. At this time, however, it is unknown if these training needs will be met incidental to whatever schedules are otherwise established for tactical sustainment training in the CCTT. Not only do different knowledge and skills have differing retention rates (e.g., assembly and disassembly of a rifle as compared to inputting multiple codes for indirect fire support), but different media (e.g., hard copy text versus

interactive computer-based instruction) have differing capabilities to sustain them.

Training Frequency And Duration. Incorporation of communications realism training may increase the frequency and/or amount of time needed for training overall. This is a consideration in addition to that of sustaining tactical communications realism skills in and of themselves. Tactical communications skills are, after all, additional skills that, currently, often do not receive a great deal of attention. Further, if the realism feature cannot be turned off, it may slow the skill acquisition rate for other collective tactical tasks (see earlier discussion on entry level skills; Magill and Hall, 1990). In that case, additional training time will be needed just to reach skill levels currently achieved on these other tasks - unless training exercises are designed to avoid any communications degradation (e.g., by using only selected pieces of terrain). Avoiding terrain that would cause communications degradation may, however, result in less useful training for some tasks. On a positive note, research evidence suggests that soldiers may transfer their CCTT training, whatever skill level is achieved, to the battlefield environment better if they have experienced realistic combat disrupters - such as realistically degraded communications - during that training (Magill and Hall, 1990).

In summary, whether the frequency and duration of training in the current SIMNET is adequate or not, it would seem that more training may be needed in CCTT if communications realism skills training is added. In order to minimize the amount of additional time needed, an off-on switch of some type is required for communications realism; and it should be used selectively in accordance with the training needs and skill levels of the trainees.

Depending on what the future of communications technology brings us and how it is implemented on the battlefield, something more sophisticated than an overall communications realism off-on switch may become desirable in future simulations. Some simulations (e.g., Warfighter Simulation [WARSIM] 2000) are expected to encompass more echelons, Battlefield Operating Systems, and electronic communications capabilities. For training purposes in such settings, a communications control panel may be desirable where choices can be made regarding: Which environmental factors are simulated (e.g., terrain obstructions, weather), the extent to which their effects on communications quality are replicated (from mild to severe), the actions taken by OPFOR, and the electronic communications systems affected.

Implementing the Requirements. Crawl-walk-run structured training exercises which effectively train tactical communications skills - as well as the other skills for which CCTT has been designed - will take a systematic development

effort. Earlier, in the Research Method section, the contents of Appendices B thru D were described as FEA tools used informally by the author to address questions regarding the specifics of CCTT's communications simulation. Findings regarding these specifics will be discussed later. Here, Appendices B thru D and other considerations will be suggested as approaches toward developing CCTT exercises, TSPs, and other materials designed to satisfy maneuver training requirements which include communications realism *KSA*s.

Given the purposes of this report and of Appendices B thru D, it should not surprise the reader to find that some of the FEA and other development components listed below may be useful for questions pertaining to development of additional CCTT simulation capabilities or other issues, as well as training exercises and TSPs. Readers should use what is suitable for their particular needs. Readers should also, however, remember that these are untested draft materials.

Three implementing steps are described below: establishing training contexts, performing FEAs, and developing training materials. Overall battlefield maneuver training requirements will be suggested as a means of establishing training contexts. These provide frameworks within which communications realism FEAs can be performed. Information derived from these FEAs can then be used in developing CCTT exercises and TSPs. Training goals, objectives, and *KSA*s for tactical communications realism, described earlier in this report, can provide inputs to these steps. See Campbell, Campbell, Sanders, Flynn, and Myers (1995) for methodological discussions that focus on other tactical skills.

<u>Establish training context.</u> Contexts, or frameworks, for CCTT exercises can be outlined by selecting maneuver mission descriptors which correspond to general training requirements and CCTT capabilities. These outlines provide an overview of the tasks that could potentially be trained in a CCTT exercise. Some useful descriptors are: mission type, mission phase, echelon(s), and horizontal and/or vertical interorganizational links. Information on interorganizational links of concern can be obtained from task analyses that have been performed on Critical Combat Functions (CCFs) for several Battlefield Operating Systems at echelons of company through brigade. (CCFs have recently been redesignated as Battlefield Functions. CCF is, however, the most widely recognized name at this time.) These links constitute information pathways that are often supported by the communications equipment items we are concerned with here. See Ford, Mullen, and Keesling (1996) for a description of this work and source citations.

Example context descriptors include:

1. Mission Types: Movement to Contact (MTC), Defense in Sector (DIS), and Deliberate Attack (DATK).

2. Mission Phases: Planning, Preparation (including rehearsals), and Execution (which may include reconsolidation and reorganization).

3. Echelon(s): Platoon, Company, Company Team, Battalion, and Battalion Task Force.

4. Horizontal and/or Vertical Communication Links: From Platoon Leader to: Platoon's member tanks; other platoon leaders who are members of the same company; and Company Commander and Executive Officer; and from Company Commander to the TOC (McIlroy and Jarrett, 1995). Other links may be made available for use as backups if needed - for example, from Platoon Leader to the TOC or to an adjacent Company Commander.

Drawing on the above to create an example, a context for an Armored Platoon exercise could be: DATK; Execution; Platoon; and Interorganizational Links restricted to those within the platoon being trained, between that platoon and other platoons in the company (played by the Semi-Automated Forces [SAFOR]), and to their company commander; and from the company commander to the TOC. Graves and Myers (1996) describe development of such an exercise for the Virtual Training Program.

Perform front end analyses. The FEAs are means for gaining information and insights needed to better specify training requirements, and to develop approaches and products which can best meet these requirements. The FEAs identified for developing training for tactical communications skills include:

1. Identify Tasks Affected by Communications Quality Variations: Review the CCTT Communications Matrix (Appendix B) in conjunction with the training context descriptions listed above. This matrix allows a comparison between CCTT simulators and work stations, and CCTT communications equipment. The matrix includes all items on both axes that have been suggested in reviewed documentation as potentially being included in the CCTT at some point, now or in the future. Matrix cells activated in initial CCTT fieldings comprise, of course, only a small subset. Locate the matrix cells appropriate for the training context of concern and the anticipated CCTT capability. Use these cells as an orientation for identifying those tasks, within the potential task list originally identified, and/or situations where communications quality variations could realistically occur - given appropriate terrain features, distance, etc. For our training context example with a conventionally equipped Armor platoon (and by making a simplifying restriction that field artillery will not be made available), four communications matrix cells would be of concern. These four appear under the SINCGARS column: SAFOR's BLUFOR; SAFOR's OPFOR; Operations Center's TOC; and M1/M1A1 Simulator Modules.

2. Identify Communications Realism Characteristics: Use the "Legends for Matrix Cell Contents" (Appendix C) to identify and characterize aspects of communications realism that could occur on a real battlefield and/or be simulated in the CCTT. The aspects of communication realism that are contained in Appendix C and the realism characteristics that might be simulated are drawn from the author's experience. Appendix C should be considered to be a sample laundry list that could be improved or at least tailored to match a requirement. The Appendix C laundry list, modified as appropriate, would be applied to each of the Communications Matrix cells selected from Appendix B. In applying Appendix C, the communications realism characteristics should be identified with reference to the tasks being performed and the surrounding circumstances. Doing the latter will make the findings more easily applied to the training exercise being developed. Surrounding circumstances include training context, point in the exercise, and terrain and other conditions that would (e.g., LOS obstruction) or could (e.g., jamming) affect communications requirements and quality. The analyst may find the Matrix Cell Contents Worksheet (Appendix D) useful in documenting these findings.

This step of identifying realism characteristics can address the issue strictly from the perspective of what communications reality simulation capabilities a particular issue of CCTT actually possesses, or what could occur in the real world, or some combination of both. In addition, it may be desirable to consider what, if any, additions might be made to CCTT's communications realism simulation capability. When developing a training exercise and TSP, a combination of perspectives may be useful. One reason for taking this approach is that there may be cases of incomplete simulation or questionable verisimilitude which, if not pointed out to the trainees, could lead to less than fully effective transfer of training to combat. This will be discussed in greater detail later. As a preview of this discussion for the reader, it was found that not all characteristics of actual SINCGARS communication degradation are simulated, in the initial version at least, and, of those that are, not all of the simulations are entirely valid. Some of these discrepancies may be important from a training standpoint, while others are probably not. At this time, it appears that similar findings will be made when CCTT's IVIS simulation capability is fully examined.

3. Identify Communications *KSA*s: Tactical communications goals, objectives, and *KSA*s were presented earlier. Knowledge from the above analyses includes the training context and potential tasks to be performed, which of these tasks have communications aspects that can be affected by CCTT's communications simulation capabilities, and which of these latter tasks would be affected for the surrounding circumstances that have been selected. With this knowledge, the appropriate *KSA*s can be selected, positioned approximately within the training exercise to be developed, and tabbed for inclusion in the TSP.

4. Identify Additional Communications Realism Simulation Capabilities: To the extent that aspects of battlefield communications reality are not simulated by CCTT, the analyst may wish to evaluate which of these would be desirable additions to CCTT. A basic process for accomplishing this evaluation could consist of listing soldier tasks and mission contexts where an additional communications realism simulation capability would enhance training. Whether or not capabilities should be added is, of course, not only a question of, "What would be desirable from a training standpoint?", but, also: "If technically feasible, would it be worth the cost?" Training value ratings, cost data, and other information would provide a basis for assigning priorities to development of additional simulation capabilities.

Develop. There are at least three types of developmental efforts needed to fully implement training for communications tactical skills: equipment, software, or both; training the trainers; and structured training materials. Each of these are discussed.

1. Equipment and Software: There may be needs to develop automation or control capabilities, requiring equipment and software, for CCTT's SAFOR. To the extent, for example, that it is desired to play degraded communications realism with simulated/semiautomated BLUFOR elements or information warfare with the OPFOR, then SAFOR capabilities may need to be created, enhanced, or both. Associated with this or perhaps as a separate issue, it may be desirable to enhance the control capabilities available to the trainers. An example discussed previously may be the need to develop a communications realism off/on switch if such is not already part of the current or projected CCTT configuration.

Another equipment and software issue is provision of measures of performance that support diagnosis of trainee performance and provision of feedback in AARs. The CCTT is currently designed to record all radio Protocol Data Units (PDUs). These recordings would include, as a minimum, changes as they occur to characteristics of the transmitter, receiver, signal, and intercom. These data are essential to updating the simulation presented to and by each entity in CCTT's virtual environment. They may also be very useful for diagnosis of soldier performance and in providing feedback (Gonzalez, 1991). However, the question of whether or not these PDU data are actually necessary and sufficient, with or without transformation into another form and format, is one that cannot be answered at this time. An attempt to use the SRM in an earlier experiment (Leibrecht, Meade, Schmidt, Doherty, and Lickteig, 1994) was not successful due to the overwhelming amount of data produced. The decision was made in that experiment to discontinue use of the SRM to avoid losses of other performance data being recorded by the data logger (C. W. Lickteig, personal communication, 1 May

1996). Hence, there was no opportunity to examine the necessity and sufficiency of such PDU data within the context of the Combat Vehicle Command and Control (CVCC) experiment (Lickteig and Collins, 1995).

2. Train the Trainers: An overall training package on how to use and take full advantage of CCTT's training capabilities will be needed for the observers/controllers, trainers, work station operators, and SAFOR's BLUFOR and OPFOR personnel. This TSP component is needed, regardless of CCTT's communications realism aspects, due to the amount of knowledge required by these personnel and their turnover rates. To the extent that inexperienced personnel are expected to fill these positions (as anticipated at least for those unit sites limited to platoon training capability) then this TSP requirement is even more critical. Materials regarding how to create tactical communications problems, monitor and evaluate communications performance, intervene with OPFOR actions, when appropriate, and provide feedback especially need to be integrated into this Train the Trainer package. This is because, for most CCTT training related personnel, tactical communications *KSA*s and training strategies will be an entirely new topic in which they, themselves, have not received explicit training.

3. Structured Training Packages: Tactical communications *KSA*s can probably be best trained as a largely integral, minimally disruptive, part of exercises developed to train other mounted maneuver skills. An approach to developing crawl-walk-run structured exercises and TSPs was described earlier as a tactical communications skill acquisition strategy. An initial set of exercises and TSPs is under development to support CCTT's Initial Operational Test and Evaluation (IOT&E). The need for a "Train the Trainers" package, discussed above, has been recognized and a first effort to produce such a package will be a part of this IOT&E support program. Subsequent development of an integrated set of exercises and TSPs to support CCTT fielding should include tables and vignettes directed to communications realism *KSA*s. Training "wedges," or supplementary guidance to the instructors, would also be desirable. Examples of wedges include guidance regarding: (a) What the trainer should look for when trainees are conducting a communications mission rehearsal for a particular OPORD, and (b) when in the exercise the trainees should be trying to use an alternate communications route.

Current And Evolving CCTT Communications Simulation Capabilities, Discrepancies, and Training Issues

In describing the research method used, four unanswered questions were identified regarding the specifics of CCTT's communications simulation capabilities. The approach taken to find answers was described. The primary reason for unanswered questions was identified as CCTT's evolutionary development nature; several influencing factors were discussed.

This section will first answer the four questions and then discuss training issues suggested by CCTT's simulation discrepancies. "Discrepancies," in this case, are instances where the gathered information indicates an incomplete or less than truly accurate simulation of communications realism characteristics in initially fielded versions of CCTT. In some instances, the equipment simulated and the completeness and accuracy of their simulations are expected to continue evolving.

Current and Evolving CCTT Communications Simulation Capabilities. Unless otherwise noted, the primary source of information was an interview with John Foster, PM CATT C4I Systems Architect Engineer, on 9 May 1996. Other sources include the approved TDR (U.S. Army Armor Center and School, 1991), the most recent system specification (Loral Federal Systems, 1996), and other materials as referenced in the text. For readers interested in an overview of current and upcoming electronic systems related to the information war, some of which will be briefly mentioned here, see the 1996-97 Army Green Book (Association of the U.S. Army, 1996).

Table 4 sets a stage for the descriptions of CCTT's communications simulation capabilities to follow. It provides ratings of communications realism simulation capabilities

Table 4. Ratings of communications realism feature representation in the CCTT.

	REPRESENTATION IN CCTT		
REALISM FEATURES	Complete	Partial	None
Distance		X	
Terrain Obstructions		X	
Jamming			X
Aspect Interference			X
Electronic Interference	X		

expected to be found in initial CCTT issues, based on answers provided to the four questions. Table 4 is in the format of Table 1, which listed these same features and identified them as the ones found in CCTT requirements and specification documents. Table 4 will be directly discussed later, as needed, to begin addressing training issues that could result from the identified discrepancies.

1. Question One: Will realistic communications degradation apply only to SINCGARS; or to some of the other simulated equipment items and entities as well (e.g., AN/VRC-47 radio, MSE, TOC, OPFOR); or to all equipment items and entities?

The answer to this question is a two-part answer. The answer to the question as it is written is, "Yes, realistic communications degradation will occur for all entities where the entity is real in the sense that they are being played in a simulator or a work station by a person - be they a trainee or a station operator." For example, message traffic between a platoon leader's vehicle and the TOC - if the TOC work station or function is activated by a person in the CCTT Operations Center - will be affected by simulated distance and terrain obstructions between them. Realistic quality of message reception will be based on respective locations in the terrain database. As noted by Foster, "All radios, however they may be designated in the TDR and ORD (e.g., AN/GRC-160 and -46 radios in FIST-V, AN/VRC-47 in HMMWV), will exhibit SINCGARS realism, as appropriate, for where the radios are located on the simulated terrain. Communications between all entities (e.g., vehicles, TOC, Forward Entry Device [FED]) will be degraded by distance and terrain-based obstructions according to the CCTT Radio Model of SINCGARS."

The second part of the answer emerged from efforts to determine whether or not some equipment items would be simulated in CCTT, either initially or in the future. Some items, like an M1A1 tank, are obviously a part of the first CCTTs to be fielded. For some other items, the answers were not immediately obvious. These efforts merged with efforts to gain information regarding Question Two. Question Two is discussed next. Information comprising the second part of the answer to Question One and that information gained in response to Question Two are presented in Appendix E.

2. Question Two: Given the answer to Question One then the next question is: How will this realism evolve?

This question cannot be completely or exactly answered at this time for a number of reasons. One, of course, is the need to balance priorities for current and possible future requirements against uncertain funding levels. Perhaps a bigger reason, however, is not only the rapidity of technological progression but also the uncertainty regarding what, exactly, the resulting products will be capable of and how they will operate. Given the uncertainty of the information obtained, it is presented in Appendix E along with the "part two" answers to Question One.

3. Question Three: Exactly what realism characteristics will be simulated for which communications equipment items, entities, and linkages?

Communications realism characteristics which are simulated in the CCTT are presented first. These are followed by those characteristics where realism is not simulated.

a. Communications Realism Characteristics Which Are Simulated:

(1.) Message clarity: The CCTT radio model uses 256 square meter boxes for propagation calculations (SRM uses 50 square meter boxes). The model receives analog voice transmissions and converts each transmission into a digital version five times. The model then uses the Terrain Integrated Rough Earth Model (TIREM, a type of "knife" model) on each version to create the bit errors that would result from terrain obstruction features. The five versions are then interlevered to reach a majority decision regarding what the value of each bit should be, one or zero. The result is that the received message is as garbled or clear as it would be under realistic conditions.

(2.) Message loudness: Effects of distance on transmission power level are computed to determine the appropriate level of message loudness.

(3.) If a vehicle is traveling through a forest, then CCTT can simulate dropping an antenna and the consequent reduction in broadcast range capability to 500 meters. Both dropping and raising the antenna requires a trainee to exit the vehicle and make entries on an external keypad, thereby stopping vehicle movement and creating a notional time delay.

(4.) Vehicle position radio electronic interference is simulated. That is, a vehicle located within the LOS between two other vehicles will interrupt any communications between them whenever it transmits. No other form of friendly electronic interference is simulated nor does it appear that, for CCTT training purposes, other candidates exist.

(5.) Frequency hopping mode can be used or not used, as in real SINCGARS.

(6.) Can set up eight channels in order to play the security aspects of communications channel usage. Trainees can set up whatever frequencies are available in their unit although it does not matter to the model what frequencies they enter. The model simply plays its own frequencies. This is transparent to the trainees.

(7.) The COMSEC keys can be downloaded in order to remotely fill a new COMSEC key structure on all eight channels.

(8.) Dismounted Infantry (DI): The DI soldier, in receiving messages, and those receiving the DI soldier's transmissions, will have a somewhat unrealistic advantage even though such characteristics as distance and LOS obstruction effects will be simulated. The SINCGARS simulation places his radio position at tank gun tube height. This means that there will be less frequent LOS obstruction and, potentially, somewhat greater power then would be experienced in the real world.

b. Communications Realism Characteristics Which Are Not Simulated:

(1.) Environmental conditions: Although some visual and other effects of variations in weather, time of day, and season are simulated (e.g., the appearance and ground traction of dry and wet weather conditions, illumination appropriate for the time of day, seasonal changes in leaf color), their effects on communications are not simulated in CCTT's radio or other C4I models. All communications are simulated as if taking place under the same constant environment conditions: high noon at a particular geographical location on a clear day on 15 June. The constants selected are ones where electronic communications are not problematic for reasons of environment. Mr. Foster was also queried as to whether any effects of solar disturbances or temperature variations were simulated. The answer was "no" with regard to each. There is a temperature reading input to a model but it is a constant value as would be appropriate for the other constant conditions. A temperature reading was included only to give the ballistic computer (an actual ballistic computer is in the CCTT) the input needed to make calculations.

(2.) Dead space (sections of terrain which don't support radio transmissions) is not simulated.

(3.) Positional aspect interference will not occur realistically in CCTT.

(4.) SINCGARS power alternatives: Normal SINCGARS range is 20 kilometers (km) with no power amplification or 40 km with an amplifier (even though the 20 and 40 values might be modified by, for example, weather or soil mineral content). Further, under certain COMSEC conditions, other power settings may be established by the BSO. The value of 30 km is, however, often used as an approximation in discussions where precision is not needed. The SINCGARS power level is constant in the CCTT. The CCTT cannot enable practice in having or not having a power amplifier, or in executing a mission with differing range capabilities.

(5.) Jamming: Simulation of communications jamming by OPFOR is problematic; it cannot be done at this time. In efforts made to accomplish jamming to date, SAFOR has made extraordinarily heavy demands on the computer. The result has been computer crashes. All solutions that have been conceived of thus far would require so much programming and additional computer capacity that they are not affordable. One possibly affordable solution would be to have jamming occur stochastically, rather than deterministically. This solution, however, may not afford a realistic representation of OPFOR jamming behavior as would be experienced in combat.

While conventional SINCGARS is a focus of this report, two nonrealistic simulations of SINCGARS equipped with IVIS might be noted. The addition of IVIS capabilities, while providing many benefits, has not been without cost:

(6.) In the current live M1A2 SINCGARS with IVIS, voice overrides IVIS data transmissions. In contrast, whichever gets on the CCTT channel first (whether voice or datum) retains use of the channel until the transmission is complete. The PM CATT is trying to develop a voice/data arbitration feature so that CCTT voice transmissions will override all other transmissions as they currently do in reality.

(7.) The CCTT does not currently simulate the slowdown experienced in real world usage of IVIS when large amounts of data are transmitted. In live M1A2 SINCGARS with IVIS, the radio frequency has a short band width and a low baud rate. One result of this is that transmission of complex graphic overlays, or a lot of tactical messages within a short period of time, is very slow in the real world. The CCTT radio model does not simulate these IVIS slow-down effects; rather, transmissions are received instantly. These slowdowns may, however, be simulated at some time in the future.

4. Question Four: Can We Turn Degradation Realism Off?

The CCTT currently does not have this capability. In CCTT, realistic communications is always in play. It can be avoided only by structuring the mission scenario and selecting parts of the terrain data base where degradation will be minimal.

It is unknown at this time what would need to be done to develop an off/on "switch" for CCTT communications realism simulation. It should, however, be feasible. The reason for anticipating feasibility is that SRM reportedly has this capability: "...includes a feature for bypassing the signal propagation for specific radios. It allows any radio to be declared a "perfect radio" via a configuration file entry. A perfect radio is one that may transmit to any receiver and receive from any transmitter, regardless of the intervening distance or terrain" (Gonzalez, Pope, Tomlinson, and Van Hook, 1990, p. 42). The PM CATT will consider adding this capability, however, only if a TDR for this is submitted and approved.

Discrepancies between CCTT's Communication Simulation and Reality. Table 1 presented the communications realism features called for in the CCTT TDR, ORD, and specification documents. It was unknown from the contents of these documents which features would actually appear, what realism characteristics these features would possess, and whether or not CCTT would have an off/on switch for communications realism. Hence, four questions were identified. Information gathered in response to these questions has been presented above. The presentation was initiated with Table 4, in the same format as Table 1, to provide

a context for the reader. Table 4 summarized the information with regard to which realism features appear in the CCTT and the extent to which they are fully realistic.

The ratings of "none" for jamming and positional aspect interference listed in Table 4, and "complete" for positional electronic interference, follow clearly from the preceding information. Ratings of "partial" were given to distance and terrain obstructions. These ratings warrant some discussion.

Message loudness and clarity were found to be determined by more complex functions than just the variables of distance and terrain obstruction, in and of themselves, as specified in the requirements documents. Operationally, there are several intervening variables which modify the effects of distance and terrain obstruction on loudness and clarity. Some intervening variables are simulated realistically in the CCTT while others are not. Using the information presented above, reasons for the partial assignments are:

1. Distance: A positive plus characteristic is the addition of a simulated capability to drop the CCTT's antenna when moving through forested areas - or accidentally break it - with an accompanying drop in SINCGARS distance capability. A missing simulation capability lowers the rating, however. This is the inability to simulate installation or noninstallation of a power assist unit with appropriate consequences on SINCGARS's range capability. Also, DI communications capabilities are better than they would be in reality.

2. Terrain Obstructions: While not included in the definition of terrain obstruction used in the CCTT requirements documents, variations in message loudness and clarity do result from variations in terrain moisture (ranging from dry soil to bodies of water), composition, and mineral content. Meteorological conditions are another factor that, while not terrain obstructions in and of themselves, do affect communications capabilities both directly (e.g., fog) and indirectly (e.g., changes in soil moisture content resulting from rain). Lack of simulated dead spaces in the CCTT - which don't support radio transmissions - is a particularly clear example of the types of communications realities that are therefore missing.

Training Issues. Findings regarding CCTT's communications simulation capabilities suggest one particularly unique benefit (frequency hopping training) and, also, some training issues. The findings to be discussed here include those features receiving partial representation ratings, nonsimulated jamming, frequency hopping, and inability to turn off the realism simulation.

Distance simulation. Two deficiencies are noted above, lack of power assist simulation and the especially robust DI communications capability. It is not obvious, however, that

either represents a major problem. Correcting either one could entail costs that may not be worth the benefits gained. In the case of the DI, it is possible that it is not even feasible to make the DI more realistic. Reasons include DI simulation and work station operating characteristics, and the size of terrain blocks used for propagation calculations (256 meters X 256 meters).

Learning the effect of having versus not having a power assist unit, and what constitutes fully realistic DI capabilities, can probably take place elsewhere - rather than in the CCTT. The fact that the CCTT's 30 km range differs from 20 versus 40 km range on the real battlefield should, however, be briefed to trainees at least prior to initiating exercises where this difference could have an impact on expectations transferred to the live battlefield. Trainees should also be given this as an item to be considered during pre-mission analysis, planning, and rehearsals.

With DI, the importance of briefing trainees before and after CCTT training may depend on DI's role in an exercise. If it is a particularly important or dynamic one - where completely realistic communications would make a difference - then such briefings would be especially advisable.

Soil and meteorological simulations. The CCTT development program has placed considerable emphasis on:

1. Improving the realism of battlefield visual displays;

2. Increasing the number of battlefield environment conditions simulated (e.g., time of day and night, weather, and urban terrain; interactive dynamic terrain may be added in the future); and

3. Creating simulations of vehicle dynamics when interacting with these conditions (e.g., tank treads will slip in mud when it rains).

It would seem that the importance of simulating effects of soil and meteorological environmental conditions, in addition to distance and obstructions, on communications quality should be considered as well. Potentially, such simulations could provide considerable training value overall. They could be especially valuable for soldiers having to deploy to locations with meteorological and soil conditions markedly different from what they have trained on, and where these differences are ones impacting on communications capabilities.

Again, however, questions of feasibility and cost have to be considered. The number of variables and functional complexity of the CCTT Radio Model would increase with each condition added. Whether or not CCTT computers have the capacity and speed to handle any additional conditions, and the associated costs, would

have to be carefully balanced against anticipated training benefits.

Jamming simulation. Reasons for playing jamming are not only to provide knowledge regarding its effects, but also to teach prices paid for (1) lack of radio discipline, and (2) not using frequency hopping. J. Foster (personal communication, 9 May 1996) suggested that if a person in the CCTT Operations Center (e.g., the TOC operator) observes that a platoon, for example, is ignoring potential jamming problems then there are corrective actions that can be taken other than jamming. The corrective action can then be used as a teaching point in the AAR. The TOC operator could, for example, bring the platoon's behavior to the attention of the OPFOR and suggest delivering a few rounds of artillery fire in the platoon's immediate area. The teaching point in the AAR could be made by, as a minimum, playing back communications recordings and pointing out the OPFOR artillery fire as an example of one danger resulting from lack of radio discipline and not using frequency hopping.

Frequency hopping. The number of frequencies used in radios like SINCGARS may be several. For those radios possessing a frequency hopping capability, and set in frequency hopping mode with frequencies selected for that unit, a transmitted message is received with only some "clipping" effect. For other radios that don't have this capability, what little, if any, that is received of the message cannot be interpreted. Development of frequency hopping capabilities has contributed greatly to the United State's COMSEC capabilities.

The SINCGARS is one of the new digital equipment items capable of operating in either the frequency hopping or the non-hopping mode. These two modes are simulated in CCTT. What is of particular importance is that CCTT will become the very first environment enabling training of skills in using SINCGARS frequency hopping. For reasons to be explained next, we not only have not had a simulated environment that would allow this training - there have been only very few and limited opportunities to train frequency hopping skills in live environments. The result is that the majority of soldiers currently possess procedural knowledge only - not skill - in frequency hopping. Because using the frequency hopping mode is a complex operation, likelihood is high that it would not be used effectively on the battlefield without additional training. A result of this lack of training has been described as an inability of soldiers to "pass the tired, sleepy mind test" when trying to perform frequency hopping under battlefield conditions (MAJ J. Abbott, personal communication, 30 April 1996).

There are two major reasons why frequency hopping cannot be trained in most live environments. One reason is that it is not permitted by civilian government agencies (e.g., United States, Europe) wherever there is much demand for and use of communications frequencies. This situation holds true in every

country where regular and ham radios, televisions, telephones, etc., are heavily used for private and commercial purposes. Government agencies - ranging from Department of Defense to local police and fire departments - have priority claims on communications frequencies to meet emergency, security, and other requirements. Commercial firms and private citizens apply for and are assigned their piece of the remaining communications frequency spectrum. The problem is that using the SINCGARS frequency hopping mode can disrupt commercial, private, and national transmissions and receptions within its range to the point of totally obliterating them. It is because of both the critical COMSEC advantage provided by the SINCGARS frequency hopping capability and the current inability to train in use of it that the opportunity provided by CCTT is so important.

The second reason that our soldiers are inexperienced in using the SINCGARS frequency hopping capability is that we don't use it in joint combat or combat training with our allies either - even though some training areas may be sufficiently remote. This is not only because our radios are incompatible but also because any one of our current allies may not be an ally in a future operation. The latter is a national security issue. Especially for the latter reason, frequency hopping was not used, for example, in Operation Desert Storm.

Communications realism turnoff capability. This issue was first raised as an unanswered question having considerable impact on what can be done by way of training strategies. An ability to turn communications realism off, i.e., an answer of, "Yes, perfect radios, with no realistic degradation, can be played," is viewed as the desired answer. The advantages of having this capability as compared to the disadvantages of not having it were discussed in detail. The training strategies, presented subsequently, detailed how a realism off/on capability could be used as a part of crawl-walk-run structured training. Work-arounds were also suggested, however, in preparation for a finding that CCTT lacks this capability

Recommendations

Two categories of recommendations will be discussed. The first category will include ones regarding training development, and the second covers additions to CCTT's simulation capabilities.

Training Development Recommendations

Two recommendations for CCTT platoon training are clearly evident. They concern development of structured training and inclusion of frequency hopping as a part of this.

Structured Training. From what was known initially, it appeared that structured training would best enable CCTT's training capabilities, especially given the primary target

audiences. Close reviews of structured training and CCTT confirmed this position. Needs for structured exercises with TSPs for training purposes have become increasingly clear to TRADOC System Manager (TSM) CATT, PM CATT, and the U.S. Army Armor Center and School as well. In addition, it has been recognized that at least a limited set of structured training exercises will be needed to support the IOT&E of CCTT. This set is now under development.

It is recommended that this initial development effort be followed by a comprehensive plan and program to develop structured training exercises with TSPs which include structured crawl-walk-run communications realism training. This effort needs to be a long range one, supporting use of CCTT as it evolves from platoon to battalion capabilities, new simulation capabilities are added, and experience is gained in using CCTT. The factor of differences between mobile and fixed sites also needs to be considered. Some steps towards implementing communications realism training requirements for structured training were described earlier. These steps should be reviewed for input to plans for developing structured training for CCTT.

Frequency Hopping Training. While soldiers are provided instruction in use of the SINCGARS frequency hopping mode, opportunity to train with it in live tactical environments has been very limited. Hence, the number of soldiers able to use it efficiently and effectively may also be limited. This lack of available training environments, in combination with increasing threats of information warfare, makes CCTT's unique capability to train frequency hopping skills particularly important.

Frequency hopping has been included here as a training requirement that can be met in CCTT. It is one of the seven communications training objectives that were presented and is a part of these three *KSA*s: signal knowledge, technical and tactical procedures, and application to mission processes and tasks. A consideration affecting the efficiency and benefits of CCTT training, however, is the importance of having acquired "communications equipment procedural skills" prior to entering CCTT training. The actual frequency hopping knowledge and skill level held by today's potential CCTT trainees are not known. However, they are probably not at the level desired for entry into CCTT training.

Given the foregoing, it is recommended that:

1. Special emphasis be given to ensuring use of CCTT's frequency hopping training capability, as appropriate;

2. Frequency hopping be included as a part of selected TSPs;

3. Unit, institutional, and other training programs make special efforts to assure that, prior to CCTT training, trainees

are as knowledgeable and experienced as possible in using the frequency hopping mode; and

4. The CCTT training address restrictions on SINCGARS frequency hopping in areas where permission is denied by governing authorities.

Recommended Simulation Additions Where Cost = Value Added

Five training issues were discussed with regard to CCTT simulation capabilities:

1. Distance simulation;

2. Soil and meteorological simulation;

3. Jamming simulation;

4. Frequency hopping; and

5. Communications realism turnoff capability.

Of these, frequency hopping is the simulation capability which CCTT does possess and uniquely so. It is discussed above with regard to training development recommendations.

Here, the other four will be discussed with regard to the possibility of adding or improving CCTT's simulation capabilities so as to include them. In each case, the first question is whether or not the addition or improvement is feasible from an engineering standpoint. If the answer is "yes," then the issue becomes one of whether the costs it would entail are worth the training benefits that would be gained. Addressing the cost versus training value issue will, in most of these cases, require analyses and experience in using the CCTT for training. The attempt here is begin to articulate the nature of the cost versus training value issue for these communications realism simulation capabilities that CCTT neither possesses currently nor is planned to possess in the future.

Distance Simulation. Two problems were identified, lack of power assist simulation capability and an overly robust DI communications capability. Neither were judged to be a major problem at the platoon level and suggestions were made on how to compensate for these problems. Therefore, at this time, no recommendation is being made to create or modify these simulations. Once experience is gained in using CCTT for platoon training, however, these distance simulation problems may be found to be worth revisiting. It is suspected that power assist may be a somewhat greater concern when training the higher echelons of company and battalion where the distances between communicators will be greater.

Soil and Meteorological Simulation. The potential value of adding simulations of soil and meteorological characteristics was discussed earlier. Also, the issues of feasibility and cost were raised. It is recommended that, once experience is gained in using CCTT, the possibility of adding selected simulations be addressed. Experience may provide information on which simulations would be of greatest value. Another consideration, from the trainers' standpoint, is whether sufficient CCTT training time will be available in order to realize the benefits offered by having additional realism characteristics. If CCTT training time is too limited then the addition of more realism simulations may actually detract from the CCTT's training effectiveness. Once these questions have been answered by trainers then questions of feasibility and cost can be addressed by engineers.

Jamming Simulation. It is recommended that - if and when jamming can be simulated deterministically and at a reasonable cost - this simulation capability be developed. Jamming is one tool that can be used to teach radio discipline and the price of failure to use frequency hopping. More importantly, it can be used to train that jamming is a real and powerful OPFOR tool. Exposing BLUFOR platoons to realistic OPFOR use of this tool should be beneficial. The need for deterministic jamming simulation capability may become even greater as CCTT's company and battalion training capabilities are realized, as these soldiers should have an even greater need to be sensitive to OPFOR capabilities in electronic communications.

If the only feasible option is stochastic simulation, however, then it is recommended that this capability not be developed. Stochastic simulation of jamming would probably serve primarily to disrupt achievement of other training objectives. It is certainly not desirable for CCTT trainees to begin thinking of jamming as being simply a random and disruptive nuisance. An OPFOR really does not intend to operate randomly, even though it may appear that way at times. An OPFOR may be attempting to degrade or destroy particular message traffic in order to disrupt BLUFOR operations; or it may be attempting to make the BLUFOR think they can communicate more clearly and easily on some channels than others. In the latter case, these channels are often ones which the OPFOR can more easily monitor or affect; and knowing where to locate BLUFOR electronic communications and having them be more accessible is always an advantage for the OPFOR.

The foregoing describes jamming as a purposefully used OPFOR tool. It is for this reason that the development of a CCTT deterministic jamming simulation capability is recommended; while development of a stochastic one is not.

Communications Realism Control Capabilities. One simulation control recommended for the CCTT is the capability to play perfect, i.e., nonrealistic, SINCGARS communications. This has

been described elsewhere as an off/on switch to be used when trainees' skills are at the crawl-level with regard to the particular training objectives. An even more sophisticated possibility is that of providing a rheostat-like control of communications degradation which ranges from perfect, non-degraded communications capability to fully realistic degraded communications. Determining whether or not this latter option would be useful from a training standpoint would probably require some experimentation.

There is an additional turnoff capability that should be considered, especially to the extent that sufficient trainees move well into the walk stage or into the run stage of training. This is a different kind of turnoff capability, one that would emulate OPFOR's ability to selectively destroy communications capabilities. As jamming is an OPFOR tool for both disrupting and managing BLUFOR communications, so is the capability to selectively destroy BLUFOR communications assets. Examples of BLUFOR assets which are candidates include relay equipment for SINCGARS communications, company commander vehicles, and such communications centers as TOCs. To the extent trainees begin moving into the run stage, even at the platoon level, then information warfare becomes pertinent to maneuver training. As training moves to company and battalion echelon levels then this becomes even more relevant. The CCTT could be an especially effective medium for providing this training.

Mueller (1991) has suggested that even greater training value would be gained if warfighters were placed in a tactical training environment where BLUFOR and OPFOR are on a "level playing field" with regard to their ability to affect each other's communications assets. Mueller's attention, however, was focused on divisional command post training as provided by the Corps Battle Simulation (CBS) as a part of the Army's Battle Command Training Program (BCTP) (1991, p. 1); rather than on platoon through battalion maneuver training as in the CCTT. It was suggested above that a selective OPFOR destruction capability might be simulated in the CCTT; i.e., an OPFOR command, control, and communications counter measures (C3CM) capability. Mueller states: "One of the tenets of the BCTP Warfighter exercise is that both sides have similar advantages and disadvantages, within the constraints of their differing doctrines, tactics, and forces available. In order to maintain a level playing field, OPFOR C3CM should not be included in the exercise until BLUFOR C3CM has also been added (1991, pp. 87-88)." Consideration of BLUFOR C3CM is probably not appropriate for the CCTT in that BLUFOR planning decisions regarding C3CM generally take place at division and above, even though lower echelons may participate as execution agents (DA, 1996a, p. 3-18; DA, 1996b, pp. 6-0 - 6-17). Mounted maneuver BLUFOR elements may not have an execution role other than assigning higher priority to the OPFOR command vehicles they encounter, where such can be identified and targeting options exist. Mueller's concern for a level C3CM playing field in training should, however, be reviewed periodically with respect

to all simulations, including the CCTT, as the digital battlefield and accompanying doctrine evolves.

Summary

Tactical training needs have long existed for dealing with changes in communications capability on the battlefield. These needs are becoming ever more critical as rapid technological advancements cause electronic communications capabilities to greatly increase. These new communications capabilities can significantly enhance combat power if soldiers are able to use them skillfully. If soldiers cannot, then vulnerability and other problems can ensue. The CCTT is the first training environment - live, virtual, or constructive - to purposefully provide realistic variations in electronics communications quality as would be experienced on an actual battlefield when conducting tactical maneuvers and engagements. The CCTT, therefore, is the first training environment to address training needs for skills with regard to tactical electronic communications realities and the accompanying possibilities of degradation in message quality.

In this report, simulation-based communications realism training in CCTT has been addressed primarily within the context of Armor and Mechanized Infantry platoons equipped with conventional SINCGARS. Conventional SINCGARS is the label used here to identify the fielded issue of SINCGARS having voice capability only. This issue is found in M1A1, M2A1/2, and many other vehicles. In the future, as CCTT simulation capabilities evolve, other aspects of communications realism training will be explored. These include: company and battalion level training, and additions of new electronic communications equipment simulations having data-carrying and other capabilities. An example of the latter is the IVIS-equipped issue of SINCGARS found in M1A2.

Overall tactical communications skill requirements for the warfighter are described first. These overall training requirements translated into training goals for the platoon rather easily. The goals were then used to define platoon training objectives. Platoon *KSA*s were defined through an analysis of the objectives using descriptions of what is done by the platoon, how they do it, the communications assets available to them, and requirements for using these assets. The *KSA*s determine training content. Following the platoon *KSA* breakout, training strategies and approaches to strategy implementation are presented. The recommended overall training strategy is that of simulation-based structured training with TSPs similar to those already developed for SIMNET and Janus. The recommended approach is to develop communications vignettes and tables that can be integrated into exercises designed to achieve other, larger training objectives (e.g., movement to contact, deliberate attack). It is recommended that the communications vignettes and tables be constructed as appropriate for crawl, walk, and run

stages of learning and that degradation in communications quality be minimized or "turned off" during the crawl stage. Suggestions of training content are made for the planning, preparation, and execution phases.

As might be expected, based on their relatively limited scope of electronic communications activities, the volume of communications realism training content for platoons appears comparatively minimal. Of interest is that the training goals, objectives, and *KSA* breakouts for the platoon appear, however, to represent a relatively generic model. Although the current focus is on the platoon, the same structure may be useful for addressing maneuver company and battalion communications training needs as well.

Based on this report's preliminary findings on platoon requirements and strategies, specific details of CCTT simulation capabilities and deficiencies in meeting these requirements were identified and analyzed. The CCTT development program has been, and will continue to be, an evolutionary one. It was found that attempts to meet some requirements (e.g., jamming) have not been successful yet but could be so in the future. Other capabilities that were not a specific part of the original requirements have been successfully added (e.g., decrease in communications range capability resulting from an antenna drop or breakage). With new technological developments emerging, the desirability of adding additional CCTT communications realism simulation capabilities will probably continue to be an issue.

Recommendations are presented to implement the proposed structured training strategy and to take full advantage of CCTT's unique capability to provide training in frequency hopping. Also recommended is development of additional CCTT simulation capabilities where training value gained is found to be worth the costs. Some candidates for such development are suggested. It is recommended that, as experience with CCTT utilization is gained, the CCTT development recommendations be reviewed for translation into formal requirements and then developed as they become feasible from cost and technological standpoints.

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APPENDIX A

ACRONYM LIST

List of Acronyms

AAR	After Action Review
ABCS	Army Battle Command System
AFATDS	Advanced Field Artillery Tactical Data System
AGC2S	Army Global Command and Control System
ASAS	All Source Analysis System
ATCCS	Army Tactical Command and Control System
AWE	Advanced Warfighting Experiment
BBS	Battalion and Brigade Battle Simulation
BCTP	Battle Command Training Program
BLUFOR	Blue Force
BN/TF	Battalion/Task Force
BOS	Battlefield Operating Systems
BSO	Battalion Signal Officer
C3CM	Command, Control, and Communications Counter Measures
C4	Command, Control, Communications, and Computers
C4I	Command, Control, Communications, Computers, and Intelligence
CALL	Center for Army Lessons Learned
CATT	Combined Arms Tactical Trainer
CBS	Corps Battle Simulation
CCFs	Critical Combat Functions
CCTT	Close Combat Tactical Trainer
CECOM	U.S. Army Communications and Electronics Command
CMF	Career Management Field
COA	Course of Action

COBRAS	Combined Arms Operations at Brigade Level Realistically Achieved through Simulation
COMEX	Communications Exercise
COMSEC	Communications Security
CTCP	Combat Trains Command Post
CVCC	Combat Vehicle Command and Control
DA	Department of the Army
DARPA	Defense Advanced Research Projects Agency
DATK	Deliberate Attack
DI	Dismounted Infantry
DIS	Defense in Sector
DIS	Distributed Interactive Simulation
DMD	Digital Message Device
DTIC	Defense Technical Information Center
EAC	Echelons above Corps
ECAC	Electromagnetic Compatibility Analysis Center
ECCM	Electronic Counter-Countermeasures
ECM	Electronic Countermeasures
EPLRS	Enhanced Position Location and Reporting System
ERIC	Educational Resources Information Center
FAADS	Forward Area Air Defense System
FABTOC	Field Artillery Battalion TOC
FBCB2	Force XXI Battle Command Brigade and Below
FDC	Fire Direction Center
FEAs	Front End Analyses
FED	Forward Entry Device
FH	Frequency Hopping

FIST-V	Fire Integration Support Team Vehicle
FM	Frequency Modulation
FS WS	Fire Support Work Station
GVLLD	Ground Vehicle Laser Locator Designator
HLA	Future High Level Architecture
HMMWV	High Mobility Multipurpose Wheeled Vehicle
HumRRO	Human Resources Research Organization
IOT&E	Initial Operational Test and Evaluation
IVIS	Inter-Vehicular Information System
KSA	Knowledge, Skill, and Attitude
LOS	Line-of-Sight
MAPEX	Map Exercise
MATRIS	Manpower and Training Research Information System
MCS	Maneuver Control System
MSE	Mobile Subscriber Equipment
MTC	Movement to Contact
MTP	Mission Training Plan
NTIC	National Technical Information Center
OPFOR	Opposing Force
OPORD	Operations Order
ORD	Operational Requirements Document
P3I	Preplanned Product Improvement
PM	Project Manager
SAF or SAFOR	Semi-Automated Forces
SIMNET	Simulation Network
SIMUTA	Simulation-Based Multiechelon Training Program for Armor Units

SINCGARS	Single Channel, Ground/Air Radio System
SINCIP	SINCGARS Improved Product
SME	Subject Matter Expert
SRM	SINCGARS Radio Model
STRICOM	U.S. Army Simulation, Training, and Instrumentation Command
TAC CP	Tactical Command Post
TACFIRE	Tactical Fire Direction System
TACP	Tactical Air Command Post
TDR	Training Device Requirement
TEWT	Tactical Exercise Without Troups
TIREM	Terrain Integrated Rough Earth Model
TOC	Tactical Operations Center
TSM	TRADOC System Manager
TSP	Training Support Package
UMCP	Unit Maintenance Command Post
WARSIM 2000	Warfighter Simulation 2000

APPENDIX B

CCTT COMMUNICATIONS MATRIX

DESCRIPTION OF:

____ REAL WORLD

____ REQUIREMENT

____ PRODUCTION:

Production Date/Lot #:

Units to be Equipped/
Dates/Quantity:

	COMMUNICATIONS EQUIPMENT																
SIMULATORS & WORK STNS	SINCGARS	IVIS	DMD	FED	AN/VRC-47 radio (HMMWV)	AN/GRC-160 radio (FIST-V)	AN/GRC-46 radio (FIST-V)	MSE	EPLRS	TACFIRE	AFTDS (FSC2)	GLLD	B2C2	ABCS	FBCB2	AGC2S	ATACCS
SAFOR BLUFOR																	
OPFOR																	
OPERATIONS CENTER BDE HQ (TAC CP)																	
TOC																	
ALOC/CTCP [CSS only]																	
ALOC/CTCP [CSS + S1]																	
ENGR WS																	
FS WS																	
FABTOC																	
Mortar FDC																	
UMCP																	

	COMMUNICATIONS EQUIPMENT																
SIMULATORS & WORK STNS	SINCGARS	IVIS	DMD	FED	AN/VRC-47 radio (HMMWV)	AN/GRC-160 radio (FIST-V)	AN/GRC-46 radio (FIST-V)	MSE	EPLRS	TACFIRE	AFTDS (FSC2)	GLLD	B2C2	ABCS	FBCB2	AGC2S	ATACCS
OPERATIONS CENTER (cont.) HMMWV as scout, utility, & special purpose vehicles																	
TACP																	
CAS																	
Army Aviation Element																	
ADA Element																	
Medical Plt																	
Bde Support Area																	

SIMULATORS & WORK STNS	COMMUNICATIONS EQUIPMENT																
	SINCGARS	IVIS	DMD	FED	AN/VRC-47 radio (HMMWV)	AN/GRC-160 radio (FIST-V)	AN/GRC-46 radio (FIST-V)	MSE	EPLRS	TACFIRE	AFTDS (FSC2)	GLLD	B2C2	ABCS	FBCB2	AGC2S	ATACCS
SIMULATOR MODULES M1/M1A1																	
M1A2																	
M2A1/M3A1																	
M2A2/M3A2																	
M2A3/M3A3																	
FIST-V M981A3																	
M9012 ITV																	
M113A3 APC																	
M8 AGS																	
DI System																	

APPENDIX C

INSTRUCTIONS AND LEGEND FOR MATRIX CELL CONTENTS WORKSHEET

INSTRUCTIONS AND LEGEND FOR MATRIX CELL CONTENTS WORKSHEET

Four categories of description are presented: Communications Equipment Realism Characteristics, Tasks and Echelons Affected by Having vs. Not Having Communications Reality, Information Source, and Notes. Analysts should add or subtract categories and category items as suitable for their purposes. The descriptions are to be developed with reference to each cell of the Communications Matrix determined to be relevant to the problem. Additional cells can, of course, be added to the Communications Matrix if needed. A worksheet (see Appendix D) is one means for compiling descriptions. For some purposes, it may be useful to enter some form of the compiled descriptions into the Communications Matrix format.

COMMUNICATIONS EQUIPMENT REALISM CHARACTERISTICS; that is, can communications quality be degraded under some real world circumstances and, if so, is it similarly degraded through simulation. Select those communications realism scale values (1 through 6 and/or 6a through 6n) which describe the real world and/or the simulation. Use N\A if Not Applicable.

0 = Equipment not present at all but could/should be

1 = Equipment physically present (nonoperational and nonfunctional)

2 = Equipment physically present (operational but nonfunctional)

3 = Equipment functional but no realistic/deterministic variations in communications quality

4 = Frequency hopping mode

- **a.** frequency hopping mode only
- **b.** no frequency hopping mode
- **c.** can choose either mode

5 = Equipment functional with combat damage variations in communications quality due to:

- **a.** jamming
- **b.** destruction
- **c.** other

6 = Equipment functional with realistic/deterministic variations due to:

• Enter a in front of each characteristic to which the equipment responds realistically.

• Circle **Y** if the realistic response can be turned off. Circle **N** if realism is always in effect.

• *Describe* the variations that occur due to each characteristic (e.g., voice: fading due to distance, clipping due to frequency hopping; data: errors, not received, dropping out of cue; graphics: transmitted/received slowly; etc.)

Describe

___ **a.** distance (**Y** **N**):

___ **b.** terrain and/or objects (e.g., building, another tank) blocking line of sight (**Y** **N**):

___ **c.** dead space (**Y** **N**):

d. voice reception quality in frequency hopping vs. nonhop modes (**Y** **N**):

e. electronic interference (position, other) (**Y** **N**):

___ **f.** system capacity (**Y** **N**):

___ **g.** baud rate limitations (**Y** **N**):

___ **h.** frequency-limitations, capabilities thereof (**Y** **N**):

___ **i.** OPFOR can destroy SINCGARS relay nodes:

___ **j.** OPFOR can otherwise react intelligently to BLUFOR's lack of radio discipline by *(describe)*:

___ **k.** OPFOR can manipulate BLUFOR's use of frequencies or otherwise deceive the BLUFOR *(describe)*:

___ **l.** Terrain:

(**1**) Size of terrain allows for troop movement beyond range of relay nodes.

(**2**) Features of terrain allow for maneuver outside of line of sight.

___ **m.** BLUFOR can play logistics actions and delays in replacing/installing relay nodes.

___ **n.** Other (e.g., terrain composition, weather). Identify and *describe*:

TASKS AND ECHELONS AFFECTED BY HAVING vs. NOT HAVING COMMUNICATIONS REALITY:

P = platoon. Develop soldier task lists for each simulator and work station and assign numbers to the tasks. Entry on worksheet or in Matrix cell would the be P3, P7, P8, etc. For "P3," "P" would designate "platoon" and "3" would designate the task identified as "task number 3" in the task list.

C = company. Same as above with examples of C2, C7, C9, etc.

B = battalion. Same as above with examples of B1, B10, etc.

INFORMATION SOURCE:

Reviewed document: Assign numbers or other identifiers to the reviews and enter in the worksheet and/or Matrix.

Interview: keep list with names, dates, phone numbers, and content. Assign letters or other identifiers for use in matrix.

NOTES

DEFINITION OF POSSIBLE CAUSES OF VARIATIONS IN COMMUNICATIONS QUALITY IN CCTT (System specification for Close Combat Tactical Trainer Device 17-159, Naval Training Systems Center (1990), p. 11):

Realistic/Deterministic: variations in transmission/reception quality as would realistically occur as a function of:

* operating environment and location factors;

* BLUFOR actions or lack of actions to deal with the operating environment and location features;

* OPFOR tactical actions made possible by BLUFOR's lack of radio discipline, nonuse of SINCGARS frequency hopping mode, poor COMSEC, etc.

* OPFOR manipulations/deceptions affecting BLUFOR's use of frequencies

Combat Damage: variations in quality of communications as a result of OPFOR actions like jamming or destruction of a relay node, TOC, whatever.

Stochastic: another variation sometimes used in simulation is one based on stochastic models of equipment failure using reliability data on such things as mean time between failure and mean time to repair. Not currently included as an item under the first category, Communications Equipment Realism Characteristics.

TRAINING NOTE: LOS vs. satellite capability (a way to explain why no degradation problems due to 6a or 6b in a training exercise).

APPENDIX D

MATRIX CELL CONTENTS WORKSHEET

MATRIX CELL CONTENTS WORKSHEET

This worksheet is organized according to the CCTT Communications Matrix. That is, the simulator/work station being described (selected from the vertical axis of the Matrix) is identified first. A check mark can indicate whether the description of the simulator/work station pertains to: the real entity in the real world, or what is stated in the TDR as a requirement, or what is stated in the specification as what is to be developed. If it is a production issue being described then other details can be noted (two suggestions are provided). The final identifier in this section is a check to indicate which communications characteristic(s) (voice, data, and/or graphics) is described on this worksheet.

Next, the equipment items appearing on the horizontal axis of the Communications Matrix are listed. The analyst may want to use one worksheet for each of the desired items or, instead, do some form of consolidation. Entries for each of the selected items would derive from use of Appendix C, Legend for Matrix Cell Contents Worksheet, and any other information the analyst finds useful.

The final two items on the worksheet pertain to the soldier tasks affected by communications realism simulation or the lack thereof, and the information sources. How these are or are not used by the analyst will depend on how the analyst has otherwise decided to record the information.

SIMULATOR/WORK STATION: ____

_____ **REAL WORLD**

_____ **REQUIREMENT**

_____ **PRODUCTION:**

Production Date/Lot #:

Units to be Equipped/Dates/Quantity:

COMMUNICATIONS EQUIPMENT CHARACTERISTICS with respect to:
___ **Voice** ___ **Data** ___ **Graphics**

SINCGARS:

IVIS:

DMD:

FED:

AN/VRC-47 radio (HMMWV):

AN/GRC-160 radio (FIST-V):

AN/GRC-46 radio (FIST-V):

MSE:

EPLRS:

TACFIRE:

AFATDS (FSC2):

GLLD:

B2C2:

ABCS:

FBCB2:

AGC2S:

ATACCS:

TASKS AND ECHELONS AFFECTED BY HAVING vs. NOT HAVING COMMUNICATIONS REALITY, AS DESCRIBED ABOVE:

INFORMATION SOURCES:

Reviewed Document(s):

Interview(s):

APPENDIX E

CURRENT ENTITY REPRESENTATIONS AND PROJECTIONS FOR FUTURE COMMUNICATIONS SIMULATIONS IN THE CCTT

Responses Related to Question One (other responses to all four of the questions presented in the Results section):

- There will not be a DMD played. Instead, an FED will be simulated for the Fire Integration Support Team Vehicle (FIST-V) which, in real life, does go through a SINCGARS. Ground Vehicle Laser Locator Designator (GVLLD) will also be played in the FIST-V, but this is a laser device that does not use SINCGARS.

- The AFATDS will not be explicitly represented. The Field Artillery Battalion TOC (FABTOC) will be played, however, and play as if AFATDS existed. Given that AFATDS is being fielded to replace the Tactical Fire Direction System (TACFIRE), the existence of TACFIRE will not be simulated in any sense.

- There will be no MSE or Enhanced Position Location and Reporting System (EPLRS) simulated initially. EPLRS may, however, be a part of future CCTTs.

Responses Related to Question Two:

- An improved SINCGARS is under development. If the effort is successful, then the SINCGARS Improved Product (SINCIP) will be installed in live vehicles being used in the FXXI Brigade AWE (being held in 1997). The SINCIP will have the Tactical Internet, which is currently under development by the U.S. Army Communications and Electronics Command (CECOM). With SINCIP, SINCGARS will be the pathway for two separate channels: one channel for EPLRS (position data) and one channel for voice. This will afford one benefit of M1A2's IVIS to other vehicles: provision of vehicle location data. With SINCIP, due to the use of two channels, voice will not override data as it does in IVIS. Voice transmissions will also share an advantage possessed by EPLRS: Voice - as well as location and other data messages - will roam freely through the communications network and seek out available routings on their own. A simulated Tactical Internet Model has been successfully developed and installed in the SIMNET simulators being used in training for the AWE. If CECOM's effort to develop an actual Tactical Internet is successful, then SINCIPs may be included in future CCTTs.

- A new system called Applique' is currently under development. Applique' will provide many M1A2 IVIS-like capabilities (akin to those afforded by a modem-equipped personal computer) to all vehicles in which it is installed. Of interest to the communications issue is that it is not expected that Applique' will be installed in M1A2s; nor that IVIS and Applique' equipped vehicles will be able to communicate data to each other. It is presently anticipated that Applique' will be simulated in some CCTTs at some time in the future.

- The M2A3 vehicle and its simulator in CCTT may get a new IVIS version that will have some improvements over the M1A2 IVIS. If so, then this CCTT IVIS simulation will run in real time; that

is, large data and graphics transmissions will run slowly. Although not a topic of this report, it can be noted that the current CCTT M1A2 IVIS simulation does not realistically reflect the low baud rate of SINCGARS. Instead, transmissions are received instantly.

- Any or all of the following may be played to some extent in the future from platoon to echelons above corps (EAC): FB2C2 with Applique'; and ABCS with all the ATCCS and Sigma Star connections to the Army Command and Control System, AFATDS, All Source Analysis System (ASAS), Forward Area Air Defense System (FAADS), and Maneuver Control System (MCS).

- Research is underway towards development of a modular reconfigurable C4I that would provide a Future High Level Architecture (HLA). The intent is to be able to link CBS (and, subsequently, WARSIM 2000) to CCTT's SAFOR, thus allowing CBS connections to MCS, Phoenix, AFATDS, and possibly other CCTT entities. The intent is to move towards an HLA that can be used for joint exercises including Navy carrier ships, Army battalions, etc.